S. HRG. 110–83

NATIONAL CARBON DIOXIDE STORAGE CAPACITY ASSESSMENT ACT OF 2007, AND DEPARTMENT OF ENERGY CARBON CAPTURE AND STORAGE RESEARCH, DEVELOPMENT, AND DEMONSTRATION ACT OF 2007

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

ON

S. 731

TO DEVELOP A METHODOLOGY FOR, AND COMPLETE, A NATIONAL ASSESSMENT OF GEOLOGICAL STORAGE CAPACITY FOR CARBON DIOXIDE, AND FOR OTHER PURPOSES

S. 962

TO AMEND THE ENERGY POLICY ACT OF 2005 TO REAUTHORIZE AND IMPROVE THE CARBON CAPTURE AND STORAGE RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROGRAM OF THE DEPARTMENT OF ENERGY AND FOR OTHER PURPOSES

APRIL 16, 2007

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NATIONAL CARBON DIOXIDE STORAGE CAPACITY ASSESSMENT ACT OF 2007, AND DEPARTMENT OF ENERGY CARBON CAPTURE AND STORAGE RESEARCH, DEVELOPMENT, AND DEMONSTRATION ACT OF 2007

MONDAY, APRIL 16, 2007

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 2:30 p.m., in room SD–366, Dirksen Senate Office Building, Hon. Jeff Bingaman, chairman, presiding.

OPENING STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO

The CHAIRMAN. All right, why don't we start the hearing.

I'd like to welcome everyone here today, and to thank the witnesses who are here to testify before the committee.

This is a legislative hearing on two bills, S. 731 and S. 962. These two bills focus on two important aspects of carbon capture and storage. S. 731 focuses on assessing the national geologic storage potential for carbon dioxide, while S. 962 focuses on reauthorizing and improving the Carbon Capture and Storage Research, Development, and Demonstration Program in the Department of Energy.

This topic of reducing greenhouse gases, particularly carbon dioxide emissions, is a topic of great concern to myself, I know to Senator Domenici, and other members of the committee, as well. Carbon capture and geologic storage holds promise as a measure that can be used to mitigate global climate change while still allowing the use of fossil fuels at electricity generating plants and industrial facilities.

With discussions centered on coal use in a carbon-constrained world, carbon capture and storage may pose the most immediate solution for continued use of coal, while not contributing further to carbon dioxide emissions and global warming. As carbon sequestration research and development continues, the need becomes even greater to understand the geologic storage potential that we have in the United States, and large-scale demonstration projects are necessary to prove the commercial feasibility of carbon capture technologies and long-term carbon storage.

At this point, let me defer to Senator Domenici for any opening statement he has.

STATEMENT OF HON. PETE V. DOMENICI, U.S. SENATOR FROM NEW MEXICO

Senator DOMENICI. I want to thank you, Mr. Chairman, Senator Bingaman, first, for scheduling today's legislative hearing.

We will hear testimony today from two forward-looking bills that will help our Nation explore potential carbon sequestration. Senator Bingaman and I originally introduced S. 962, the Department of Energy Carbon Capture and Storage Research, Development, and Demonstration Act of 2007. And I'm pleased that Senator Thomas has now joined us as a cosponsor. Thank you for joining us, Senator.

S. 731, introduced by Senator Salazar and others, on National Carbon Dioxide Storage Capacity Assessment Act of 2007, this bill directs the U.S. Geologic Survey to take the important steps of assessing the feasibility of geologic sites across the Nation for the safe storage of carbon dioxide. The use of American coal in electricity generation is essential to our Nation's energy independence and security.

At present, half of our electricity is generated by firm coal, and the EIA estimates that, by 2030, 57 percent of our electricity will be derived from coal. In late March, this committee held a hearing on the Massachusetts Institute of Technology report called "The Future of Coal." One of the many messages of that report was that we must invest in developing technologies to sequester carbon from coal. Our investment will be a kind of insurance policy, to prepare us for the possibility of future constraints on carbon due to concerns about global and climate charge. I believe we must make progress to make significant advancements in coal technology overall. Carbon sequestration in geologic formations is one important avenue to explore.

In developing the technology, we must also be sure to move forward with our efforts to engage other nations, such as China and India, whose livelihood also depends largely on coal. When the technology is proven at the scale needed to capture and sequester carbon dioxide, it will be critical for the world's emerging economies to fully participate in the implementation of that technology. Our Nation's economy and our economic competitiveness rely upon a global solution to this challenge.

The two bills under consideration today will move our Nation forward on carbon sequestration. The research of that will move our Nation toward—forward on carbon sequestration research. S. 962 will increase our investment in this area, including large-scale demonstration geologic. S. 731 is a complementary bill that directs the USGS to assess the feasibility and geological sites across the Nation for the safe storage of carbon dioxide.

The Department of Energy and U.S. Geological Survey who both have made contributions and contribute to State surveyors, must also play a key role. I think it's clear that DOE will lead the research effort to develop more cost-effective technologies, but, the site selection, monitoring, and verification of these geologic formations will require interagency cooperation, and cooperation between the States and the Federal Government.

I thank the chairman for holding the hearing on these bills, and I look forward to the testimony that we're going to hear.

All I can say is, I hope that we are able to get out the size of the problem. Clearly, it is a monstrous problem to sequester the carbon dioxide we're talking about if we go that way. And looks like there's no other way of any significance yet.

Thank you very much, Mr. Chairman.

The CHAIRMAN. Well, thank you very much. Senator Tester was not able to be here, and asked that we include in the record a short statement that he wished to have included.

[The prepared statement of Senator Tester follows:]

PREPARED STATEMENT OF HON. JON TESTER, U.S. SENATOR FROM MONTANA

Mr. Chairman, thank you for holding this important hearing today regarding carbon sequestration.

Climate change is real, and I am committed to finding ways to reverse its effects. In Montana our glaciers are melting, our weather is increasingly erratic and much of the state is experiencing prolonged drought. Climate change is damaging to our economy and public safety when weather events become more catastrophic. I have become convinced that capturing and storing carbon from large emitters may be the most effective and affordable manner to reduce our emissions into the atmosphere.

Coal, oil and natural gas have long provided us with relatively stable and affordable energy sources to keep our lights on, our cars running and our homes warm in the winter. The use of these sources of energy is projected to grow in the future and their development can provide jobs, affordable energy and economic growth. But if we do not find a way to reduce the negative effect of their emissions, the consequences of climate change will far outweigh the economic growth from their development.

We are on the brink of affordable and technologically feasible carbon capture and storage on a large scale. Several demonstration projects storing carbon in the ground have proven successful and the use of carbon for enhanced oil recovery can reduce the amount of greenhouse gases released into the atmosphere and increase oil production.

Unfortunately, because of uncertainties regarding liability, regulatory framework, and overall cost, carbon sequestration in large volumes has not been demonstrated in the private sector on the scale that could reverse the effects of climate change. The government has a unique opportunity to facilitate the development of this new technology in partnership with willing private interests. The two bills being heard before the committee today provided two valuable components needed to capture and store carbon.

S. 731 directs the USGS to create a national inventory of potential geological storage sites for carbon. S. 962 will continue and strengthen the work of the Department of Energy sponsored carbon sequestration regional partnerships that are bringing academic institutions, private businesses and regulatory officials together to research, develop and deploy sequestration projects. The result of these projects will be the necessary research and data needed for private businesses to bring carbon sequestration onto a larger scale.

I wanted to once again stress my support for the development of carbon sequestration technology in general, and specifically for these two pieces of legislation I cosponsored. I believe carbon sequestration will help develop our available natural resources in a responsible and clean manner, keep our economy running strong, and find a way to combat climate change.

The CHAIRMAN. Did any other members have statements they want to have included. Senator Bunning? We will certainly include that.

[The prepared statement of Senator Bunning follows:]

PREPARED STATEMENT OF HON. JIM BUNNING, U.S. SENATOR FROM KENTUCKY

I have cosponsored both of the bills we will look at today because I believe carbon sequestration technology will be an integral part of the future of coal.

I am proud to come from a coal State that has helped power the American economy for over a hundred years. Half of our nation's electricity comes from coal. Without cheap energy from coal, Americans would pay much higher electric bills and our country would lose more manufacturing jobs and investment to foreign countries.

But the coal industry recognizes not only their importance to the economy, but also their obligations to the environment.

That is why we all agree the coal of the future will be clean coal. New technologies are under development that will reduce emissions and clean up the coal power process. Carbon sequestration will be one of those technologies.

Another new technology will be coal-to-liquid fuel production. I believe carbon capture and sequestration will be an important part of developing a domestic C.T.L. industry. I hope the chairman will arrange a hearing on the legislation I wrote with Senator Obama so we can discuss the benefits and concerns with this clean coal technology.

I believe that the U.S.G.S. mapping initiative and the D.O.E. regional partnership program will help prove the long term viability of sequestration. But I want to caution this committee that we cannot call for demonstration programs and mapping projects while at the same time asking for the government to mandate this technology. There are many issues we must address, such as long-term monitoring and liability, before going down that road.

I believe this technology has a bright future. It has been used in enhanced oil recovery for nearly 50 years. With these two pieces of legislation I believe we can move closer to reaching this goal.

Thank you Mr. Chairman.

The CHAIRMAN. And anybody else who comes up with a statement—Senator Salazar?

[The prepared statement of Senator Salazar follows:]

PREPARED STATEMENT OF HON. KEN SALAZAR, U.S. SENATOR FROM COLORADO

Thank you Mr. Chairman and Ranking Member Domenici. I want to thank you for holding today's hearing on the S. 731 and S. 962, two bills that have been introduced in this Congress, and that are intended to start our country on the path to large-scale sequestration of carbon dioxide.

The United States is the largest emitter of carbon dioxide in the world, and much of these emissions come from satisfying our energy needs. The same energy needs that fuel our homes, our cars, and our economy are hurting our planet. In February 2007, a report released by the Intergovernmental Panel on Climate Change found the levels of carbon dioxide and other greenhouse gases in the atmosphere resulting from the burning of fossil fuels have increased more than 30 percent since the Industrial Revolution. The increased levels of greenhouse gases in the atmosphere are contributing to the increased temperatures we are seeing today.

In attempting to limit emissions, one promising step we can take is to sequester carbon dioxide. Carbon sequestration is a process where carbon is captured before it is released into the atmosphere, compressed, and stored underground in geological areas such as saline formations, unmineable coal seams, and oil and gas reservoirs. Fortunately, we have significant experience in injecting large amounts of carbon dioxide into geologic formations for projects to enhance the recovery of oil. Unfortunately, in most cases, the carbon dioxide that is being injected for enhanced oil recovery (EOR) is using sources of carbon dioxide from natural sources rather than capturing it from industrial sources. We simply have not been capturing carbon dioxide from fossil fuel power plants or other industrial sources, and safely sequestering it.

My legislation, S. 731, which is a bi-partisan bill co-sponsored by Senators Bingaman, Brownback, Bunning, Casey, Lugar, Tester, and Webb, would start our country on the path to large-scale sequestration of carbon dioxide from industrial sources. Our legislation would complement and build upon the existing work of the Department of Energy's (DOE) Carbon Sequestration Program managed by the National Energy Technology Laboratory, the seven DOE regional carbon sequestration partnerships, and the recently released Carbon Sequestration Atlas of the United States and Canada.

In order to speed the deployment of carbon sequestration, industry must have a comprehensive assessment of candidate formations that are suitable for sequestering carbon. The work done to date by the DOE Carbon Sequestration Program has a number of limitations that S. 731 is designed to address. For example, S. 731 requires:

1. a rigorous, peer-reviewed methodology incorporating public consultation be developed that assesses the suitability of the candidate formations in terms of a) their capacity to store carbon dioxide, b) the potential infectivity associated with the different geologic settings, c) the potential volumes of oil and gas that

are recoverable by injection and storage of industrial carbon dioxide, and d) the risk associated with the potential storage formations;

2. once the methodology is established, USGS, as our nation's largest earth mapping agency, would work with DOE and the Environmental Protection Agency (EPA) to enhance the existing carbon sequestration mapping efforts to assess the known geologic formations based on the factors included in the peer-reviewed methodology, i.e., a) capacity to store carbon dioxide, b) rates at which carbon dioxide can be injected into them, c) the potential volumes of oil and gas that are recoverable, and d) the risk associated with the potential storage formations; and

3. that the national assessment of geological storage capacity cover all 50 states. The DOE Regional Carbon Sequestration Partnerships do not cover all fifty states, and a national assessment is needed in order to provide a complete picture of our country's geological disposal options.

This comprehensive mapping effort is going to be of critical importance to industry as it seeks to find good disposal sites, and reduce costs in transporting carbon dioxide from the industrial site where it is being produced to the geologic formation where is will be safely stored.

The timeframes called for in S. 731 are indeed aggressive, but the problem our world is facing from global warming is very real and imminent. The world's leading scientists say that we have a ten-year window of opportunity to take decisive action on global warming and avert catastrophe. Therefore, the time frames included in S. 731 are intended to balance the critical need for the information, with the time that is needed to conduct a careful methodology and assessment that builds upon existing data.

Mr. Chairman, I thank you again for holding this important hearing. I look forward to hearing from our witnesses today on their ideas speeding the sequestration of carbon from industrial sources.

The CHAIRMAN. At this point, I'll go ahead with the first panel.

We have Dr. Mark Myers, who is Director of the U.S. Geological Survey, Department of the Interior, and Mr. Tom Shope, who is the acting Assistant Secretary for Fossil Energy in the Department of Energy. So, both these gentlemen are part of the administration, as we welcome them both here to give us their views on these two bills.

Please—unless you had some preference for a different order, Dr. Myers, why don't you go ahead.

STATEMENT OF DR. MARK D. MYERS, DIRECTOR, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

Dr. MYERS. Well, Mr. Chairman and members of the committee, thank you for the opportunity to provide the Department of the Interior's views on S. 731, National Carbon Dioxide Storage Capacity Assessment Act of 2007.

The administration supports the goals of the bill and agrees that the activities authorized by this bill would address a critical information need for our Nation. The challenges addressing carbon dioxide accumulation in the atmosphere are significant, and the goals of S. 731 are an excellent step forward toward addressing the information needs related to geological storage of carbon dioxide.

Also, fuel usage, a major course of CO_2 emissions to the atmosphere, will continue in both the industrialized and developing countries; therefore, a variety of strategies are being investigated to reduce emissions and remove carbon dioxide from the atmosphere. Geological carbon sequestration is one such strategy.

S. 731 deals specifically with the geologic storage of carbon dioxide. The 2005 IPCC Special Report on Carbon Dioxide Capture and Storage indicated that if the mission reduction scenario striving to stabilize global atmospheric carbon dioxide concentrations at tar-

gets ranging from 450- to 750-parts-per-million volume, the global storage capacity of geologic formations may be able to accommodate most of the captured carbon dioxide. However, geologic storage capacity will vary on a regional and national scale, as well as by reservoir type, and a more refined understanding of that geological capacity is needed to address this knowledge gap in order to understand how much the overall storage capacity can actually be utilized.

The usable storage capacity then needs to be evaluated regarding proximity to carbon dioxide sources, an important consideration of the economic viability of carbon sequestration projects.

S. 731 directs the Secretary of the Interior, acting through the Director of the U.S. Geological Survey, to develop a methodology for conducting a national assessment of geological storage capacity for carbon dioxide, convene a review panel to evaluate the methodology, allow for a public comment period, and conduct a national assessment of geological storage capacities for carbon dioxide.

The USGS is uniquely posed to develop geologically-based methodologies to develop a national capacity for geological carbon sequestration because of our experience with national and international assessments of natural resources. We envision a national carbon dioxide storage assessment methodology that would be largely analogous to the peer-reviewed methodologies used by the USGS for oil, gas, and coal resource assessments.

In addition, the USGS knowledge of regional groundwater aquifer systems/groundwater geochemistry would allow the USGS to develop methods to assess potential storage in saline aquifers. Previous studies have isolated the existence of very large carbon dioxide storage capacities in saline aquifers, but the extent to which these capacities can be utilized remains unknown. The USGS can create a scientifically-based, multidisciplinary methodology for carbon dioxide storage assessment that can be consistently applied on the national scale.

The USGS looks forward to coordinating and cooperating with the Department of Energy, the Environmental Protection Agency, and other Department of the Interior bureaus, State geological surveys, and other relevant entities that are carrying out carbon sequestration activities to ensure the usefulness and success of this assessment.

In conclusion, the administration agrees with the goals of the bill to develop a standard peer-reviewed methodology to assess the Nation's geologic storage capacity of carbon dioxide and produce a national-scale assessment using this methodology. The activities authorized in this bill would ultimately result in a geological-based robust and peer-reviewed national-scale assessment that's consistent across regions and usable for a variety of purposes.

The administration does have concerns about the timeframes established in the bill and the mandatory language, and we look forward to working with the committee to address the revisions necessary to the bill to ensure that we can produce the best possible product for this large and important undertaking.

Thank you, Mr. Chairman, for the opportunity to present the testimony. I'd be pleased to answer any questions you or members of the committee might have.

[The prepared statement of Dr. Myers follows:]

PREPARED STATEMENT OF DR. MARK D. MYERS, DIRECTOR, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

Mr. Chairman and Members of the Committee, thank you for the opportunity to provide the Department of the Interior views on S. 731, "National Carbon Dioxide Storage Capacity Assessment Act of 2007."

The Administration supports the goals of the bill and agrees that the activities authorized by this bill would address a critical information need for our nation. We cannot, however, commit to meeting the timeframes established by this bill. We could support this bill if it were amended to address our concerns regarding the bill's mandatory language and statutorily prescribed timeframes. The activities authorized by this bill would need to compete among the Administration's other priorities for funding. I look forward to working with the committee to address these issues.

GEOLOGIC CARBON SEQUESTRATION

The challenges of addressing carbon dioxide accumulation in the atmosphere are significant and the goals of S. 731 are a step forward toward addressing information needs related to geologic storage of carbon dioxide. Fossil fuel usage, a major source of carbon dioxide emissions to the atmosphere, will continue in both industrialized and developing countries. Therefore, a variety of strategies are being investigated to reduce emissions and remove carbon dioxide from the atmosphere. Geologic carbon sequestration is one such strategy.

Numerous carbon dioxide concentration stabilization targets have been modeled to evaluate the technical and economic feasibility of carbon dioxide capture and storage in the context of a mitigation strategy. The current atmospheric carbon dioxide concentration is approximately 380 parts per million volume and rising at a rate of approximately 2 parts per million volume annually, according to the most recent information from the Intergovernmental Panel on Climate Change (IPCC). The fraction of carbon emissions from all sources that must be eliminated or sequestered to impact the magnitude of climate change is large. For example, to stabilize carbon dioxide concentrations at about 550 parts per million volume, the amount of carbon dioxide requiring elimination or sequestration may be as much as 70 percent. Reductions of this magnitude could involve implementation of several mechanisms, including geological and biological sequestration, fuel shifts from fossil sources to renewable biological sources, increased electricity generation from solar and wind systems and nuclear power, and increased efficiency of power generation, transmission, and end use. Each of these mechanisms has distinct geological, hydrological, ecological, economic and social implications that must be assessed on a wide range of scales, from molecular to basin scales, to allow rational policy discussions and decisions on implementation and deployment of technologies.

Geological storage of carbon dioxide in porous and permeable rocks involves injection of carbon dioxide into a subsurface rock unit and displacement of the fluid or formation water that initially occupied the pore space. This principle operates in all types of potential geological storage formations such as oil and gas fields, deep saline water-bearing formations, or coal beds. Because the density of injected carbon dioxide is less than the density of formation water, carbon dioxide will be buoyant in pore space filled with water and rise vertically until it is retained beneath a nonpermeable barrier (seal). A critical issue for evaluation of storage capacity is the integrity and effectiveness of these seals.

VIEWS ON S. 731

S. 731 deals specifically with the geologic storage of carbon dioxide. The 2005 IPCC Special Report on *Carbon Dioxide Capture and Storage* indicated that, in emissions reductions scenarios striving to stabilize global atmospheric carbon dioxide concentrations at targets ranging from 450 to 750 parts per million volume, the global storage capacity of geologic formations may be able to accommodate most of the captured carbon dioxide. However, geologic storage capacity may vary on a regional and national scale, and a more refined understanding of geologic storage capacity is needed to address this knowledge gap.

S. 731 requires the Secretary of the Interior, acting through the Director of the U.S. Geological Survey (USGS), to develop a methodology for conducting a national assessment of geological storage capacity for carbon dioxide, convene a review committee to evaluate the methodology, allow for a public comment period, and conduct a national assessment of geological storage capacity for carbon dioxide.

While the USGS does not currently have experience assessing the national capacity of geologic sequestration of carbon dioxide, USGS experience with national and international assessments of natural resources could allow USGS to develop geologically based methodologies to assess the National capacity for geologic sequestration of carbon dioxide. We envision the national geologic carbon dioxide storage assessment methodology would be largely analogous to the peer-reviewed methodologies used in USGS oil, gas, and coal resource assessments. In addition, the USGS' knowledge of regional groundwater aquifer systems and groundwater chemistry would allow USGS to develop methods to assess potential storage in saline water-bearing formations ("saline aquifers"). Previous studies have postulated the existence of very large carbon dioxide storage capacities in saline aquifers, but the extent to which these capacities can be utilized remains unknown. The USGS could create a scientifically based, multidisciplinary methodology for geologic carbon dioxide storage assessment that can be consistently applied on a national scale.

Under this bill, the USGS would coordinate and cooperate with the Department of Energy, the Environmental Protection Agency, other Department of Interior bureaus, State geological surveys and other relevant entities that are carrying out carbon sequestration activities to ensure the usefulness and success of the assessment. Many states already have some storage capacity data already developed, most of which is compiled in the National Carbon Sequestration Atlas published by the Department of Energy. The data for this atlas was compiled by the Regional Carbon Sequestration Partnerships which my colleague from the Department of Energy previously mentioned.

CONCERNS WITH S. 731

Section 3 of the bill requires that the Secretary develop a methodology within 270 days of enactment of the bill with subsequent mandatory requirements for review and comment, independent verification, and final publication. Additionally, Section 4 of the bill requires the Secretary to complete a national assessment within two years after the methodology is finalized. The Administration supports a national assessment, but the activities authorized under this bill must compete under the normal prioritization, budgetary, and funding processes. To ensure that this happens, the bill would have to be amended to provide flexible timeframes that will ensure that the national assessment will be funded consistent with other Administration and Congressional priorities. The bill does not provide sufficient time to develop the methodology and carry out the required assessment. USGS needs flexibility to ensure that we are able to develop the best product. Furthermore, to ensure appropriate flexibility in budgetary management, the Administration recommends that this bill be amended to authorize rather than require the national assessment. We would like to work with the committee to revise the bill to address these issues. If the bill is amended to satisfactorily address these concerns, the Administration would support it.

In conclusion, the Administration agrees with the goals of the bill to develop a standard, peer reviewed methodology to assess the nation's geologic storage capacity of carbon dioxide and produce a national scale assessment using this methodology. We would also like to underline the importance of using a collaborative and non-duplicative inter-agency approach to build on the existing data, including DOE's National Carbon Sequestration Atlas. The activities authorized in this bill would ultimately result in a geologically based, robust, and peer-reviewed national scale assessment and I look forward to working with the Committee on important revisions to the bill to ensure that the Administration would be able to support it.

Thank you, Mr. Chairman, for the opportunity to present this testimony. I will be pleased to answer questions you and other Members of the Committee might have.

Senator DOMENICI. Thank you, Doctor.

The CHAIRMAN. Yes, thank you very much.

Mr. Shope, why don't you go right ahead.

STATEMENT OF THOMAS D. SHOPE, ACTING ASSISTANT SECRETARY FOR FOSSIL ENERGY, DEPARTMENT OF ENERGY

Mr. SHOPE. Thank you, Mr. Chairman.

Mr. Chairman, Ranking Member Domenici, members of the committee, it's an honor for me to appear before you today to discuss

the Department of Energy's sequestration program and Senate bills S. 731 and S. 962.

As you know, fossil fuels must, and will, play a critical role in the Nation's future energy strategy, and sequestration—that is the capture, transportation, and underground storage of carbon dioxide—is one of the pathways DOE is pursuing to allow the continued use of fossil fuels while reducing CO_2 emissions.

DOE is taking a leadership role in the development of carbon capture and storage technologies. Successful research and development will provide carbon-control technologies that break through current technical and economic barriers, making widespread deployment of those technologies possible.

Our carbon sequestration program has as its goal the development of technologies that will allow for the safe long-term storage of carbon dioxide while holding any increase in the cost of electricity to less than 10 percent. DOE's seven regional carbon sequestration partnerships are developing and validating the technology and national infrastructure needed to implement carbon dioxide capture and storage in different regions of the Nation. The regional partnerships initiated in 2003 began by identifying the most promising opportunities for carbon storage in their regions, and are currently performing 25 geologic field tests and 11 terrestrial field tests, as well as other verification, permitting, and public outreach activities.

Large-volume testing, scheduled to begin in fiscal year 2008, will demonstrate CO_2 capture, transportation, injection, and storage at a scale equivalent to future commercial deployments. Given the opportunities provided by the fiscal year 2007 operations plan, DOE will accelerate these activities by initiating them in 2007. These large-volume deployment tests are expected to provide results that will be used in the design of a FutureGen project, the coal-based powerplant of the future, which will produce both hydrogen and electricity, while capturing and storing CO_2 emissions.

It is important to note that the recently published Carbon Sequestration Atlas of the United States and Canada, compiled using data from the regional partnerships, the U.S. Geological Survey and elsewhere, estimates carbon dioxide sink capacity sufficient to hold several hundred years of domestic U.S. emissions.

The two bills under discussion this afternoon, S. 731 and S. 962, highlight Congress's recognition of the importance of carbon capture and storage technologies. I would like to share some thoughts on those provisions of the bills related to the Department's sequestration program.

On S. 731, the National Carbon Dioxide Storage Capacity Assessment Act of 2007, DOE agrees that sound storage estimates are extremely important to the success of the program. DOE, through its sequestration program, regional partnerships, and other actions, has been working on this effort since 2003. Recently, we have made publicly available the Carbon Sequestration Atlas of the United States and Canada and the National Carbon Sequestration Database and Geographical Information System, or NATCARB for short. Our goal is for the atlas to be continually improved and updated with additional data from all sources, avoiding duplication of effort between agencies. Collaboration with the USGS strengthens

our efforts. And I believe that my colleague from the USGS has aptly put that forward.

Regarding S. 962, the Carbon Capture and Storage Research, Development, and Demonstration Act of 2007, DOE agrees with the majority of the provisions, including the need to expedite and carry out large-scale testing of sequestration in various geologic formations in different parts of the country in order to provide information on the cost and feasibility of sequestration technologies.

The regional partnerships are focused on exactly these issues and should begin the process of conducting large-volume tests by the end of this fiscal year. Most of the objectives and activities called for in the bill are consistent with those of the DOE's sequestration program, including the cost-sharing requirements.

As to funding for the carbon sequestration program core activities and the regional partnerships, I should note that funding beyond the 3 years of appropriations authorized in the bill will be required.

While there are other provisions of the bill that address technical issues that could benefit from clarification, the Department fully supports the objectives of the bill and the recognition of the important role that carbon capture and storage plays in mitigating carbon dioxide emissions.

Mr. Chairman, members of the committee, this completes my prepared statement, and I'd be happy to answer any questions you may have.

[The prepared statement of Mr. Shope follows:]

PREPARED STATEMENT OF THOMAS D. SHOPE, ACTING ASSISTANT SECRETARY FOR FOSSIL ENERGY, DEPARTMENT OF ENERGY

Mr. Chairman, members of the Committee, it is a pleasure for me to appear before you today to discuss the Department of Energy's Sequestration Program and Senate Bills 731 and 962.

CARBON SEQUESTRATION AND FOSSIL FUELS

The availability of affordable energy is an important component of economic growth. The use of fossil fuels, however, can result in the release of emissions with potential impacts on the environment. Of growing significance are emissions of carbon dioxide (CO_2) which contribute to global climate change.

Balancing the economic value of fossil fuels with the environmental concerns associated with fossil fuel use is a difficult challenge. Carbon capture and storage technologies provide a key strategy for reconciling energy and environmental concerns. Geologic sequestration—the capture, transportation to an injection site, and long-term storage in a variety of suitable geologic formations—is one of the pathways that the Department of Energy (DOE) is pursuing to allow the continued use of fossil fuels while reducing CO_2 emissions.

DOE is taking a leadership role in the development of carbon capture and storage technologies. Through its Carbon Sequestration Program—managed within DOE's Office of Fossil Energy and implemented by the National Energy Technology Laboratory (NETL)—DOE is developing both the technologies through which geologic carbon sequestration could potentially become an effective and economically viable option for reducing CO_2 emissions. The Carbon Sequestration Program works in concert with other programs within the Office of Fossil Energy that are developing the complementary technologies that are integral to coal-fueled power generation with carbon capture: Advanced Integrated Gasification Combined Cycle, Advanced Turbines, Fuels, Fuel Cells, and Advanced Research. Successful research and development could enable carbon control technologies to overcome the various technical and economic barriers in order to produce cost-effective CO_2 capture and enable wide-spread deployment of these technologies.

DOE'S CARBON SEQUESTRATION PROGRAM

The Carbon Sequestration Program, with a Fiscal Year 2008 budget request of $86 million (including Sequestration R&D by federal employees under the Program Direction line), encompasses two main elements of technology development for geologic sequestration: Core R&D and Validation and Deployment. The Core R&D element converts technology needs in several focus areas into technology solutions that can then be validated and deployed in the field. Lessons learned from the field tests are fed back to the Core R&D element to guide future research and development. Through its Integrated Gasification Combined Cycle, Fuels, Sequestration, and Advanced Research programs, DOE is investigating a wide variety of separation techniques, including gas phase separation, absorption, and adsorption, as well as hybrid processes, such as adsorption/membrane systems. Current efforts cover not only improvements to state-of-the-art technologies but also the development of several revolutionary concepts, such as metal organic frameworks, ionic liquids, and enzyme based systems. The ultimate goal is to drive down the energy penalty associated with capture so that geologic sequestration can be done while keeping any increase in the cost of electricity to less than 10 percent.

REGIONAL CARBON SEQUESTRATION PARTNERSHIPS

One of the key questions regarding geologic sequestration is the ability to store CO_2 in underground formations with long-term stability (permanence); this requires monitoring and verification of the fate of the CO_2, to ensure that the science is sound and ultimately gains public acceptance. Answering this question is the responsibility of DOE's Regional Carbon Sequestration Partnerships (RCSPs), which are developing and validating the technology, and national infrastructure needed to implement geologic sequestration in different regions of the Nation.

Collectively, the seven RCSPs represent regions that account for 97 percent of coal-fired CO_2 emissions, 97 percent of industrial CO_2 emissions, 97 percent of the total land mass, and essentially all the geologic storage sites in the U.S. potentially available for carbon sequestration. The RCSPs are evaluating numerous geologic sequestration approaches in order to determine those best suited for specific regions of the country. They are also developing the framework to validate and deploy the most promising technologies for geologic sequestration.

A THREE-PHASE APPROACH

The RCSP Initiative takes a three-phased approach. The first, Characterization Phase, was initiated in 2003 and focused on characterizing regional opportunities for carbon capture and storage, identifying regional CO_2 sources and storage formations. The Characterization Phase was completed in 2005 and led into the current Validation Phase, which focuses on field tests to validate the efficacy of geologic sequestration technologies in a variety of storage sites throughout the U.S. Using the extensive data and information gathered during the Characterization Phase, the seven RCSPs have identified the most promising opportunities for field tests to validate the efficacy of geologic sequestration technologies in a variety of storage sites throughout the U.S. Using the extensive data and information gathered during the Characterization Phase, the seven RCSPs identified the most promising opportunities for carbon storage in their Regions and commenced geologic field tests. In addition, the RCSPs are verifying regional geologic sequestration capacities initiated in the first phase, satisfying project permitting requirements, and conducting public outreach and education activities.

The third phase, or Deployment Phase for large-volume testing. scheduled to begin in FY 2008, will demonstrate the feasibility of CO, capture, transportation, injection, and storage at a scale equivalent to future commercial deployments. Given the opportunities provided by the FY 2007 Operations Plan, DOE will initiate these activities in 2007.

These large-volume deployment tests are expected to provide results that will be used in design of the FutureGen project, which will produce both hydrogen and electricity from a highly efficient and technologically sophisticated power plant while capturing and storing CO_2 emissions. The geologic structures to be tested during these large-volume storage tests will serve as potential candidate sites for the future deployment of technologies demonstrated in the FutureGen Project as well as the Clean Coal Power initiative, which will complete a solicitation for carbon capture technologies at commercial scale in 2008.

The Regional Partnerships, the National Carbon Sequestration Database and Geographical Information System (NATCARB), and NETL have created a methodology to determine the capacity for CO_2 storage in the United States and Canada and an

Atlas from data generated by the RCSPs and other databases including the United States Geological Survey's (USGS) National Coal Resources Data System, QW Database, EROS Database. Based on data displayed in the *2006 Carbon Sequestration Atlas of the United States and Canada,* the aggregate CO_2 sink capacity—including saline formations, unmineable coal seams, and oil and natural gas formations—is estimated to hold several hundred years of total domestic U.S. emissions.

SENATE BILLS 962 AND 731

Senate bills 962 and 731 highlight Congress's recognition of the importance of storage technologies. I would like to share with you some thoughts on these recent bills, specifically related to their relevance to the Sequestration Program.

On S. 731, the National Carbon Dioxide Storage Capacity Assessment Act of 2007, we agree that knowing the potential for storage and applying a good methodology to derive storage estimates is extremely important. DOE, through its Sequestration Program and Regional Partnerships and NATCARB, has been improving our knowledge base in this area since 2003, and released an initial U.S. Assessment this month. The assessment is based on methodology that has been vetted by geologic experts throughout the country. We welcome additional data from all sources, and as it becomes available, the Atlas will be improved and updated. We will work to avoid redundancy and duplication between the work conducted by the Regional Partnerships and other sources. We believe that collaboration with USGS strengthens our efforts. We note that the USGS has been involved with DOE's program over the last several years, including participation in a small scale CO_2 injection into the FRIO formation in Texas. I will let my colleague from USGS provide more detailed comments on S. 731.

Regarding S. 962, the Carbon Capture and Storage Research, Development and Demonstration Act of 2007, DOE agrees with the majority of its provisions. We agree that there is a need to expedite and carry out large-scale testing of storage in a range of geologic formations in different parts of the country to provide information on the cost and feasibility of geologic sequestration technologies.

The Regional Partnerships are focusing on these exact issues and will conduct large volume tests during the Phase III, Deployment Phase. Efforts are underway to have some of the Regional Partnerships starting the Phase III efforts by the end of this fiscal year with the intent to inject CO_2 as soon as possible, with potential for some injections to occur by the end of FY 2008. To comply with public and regulatory requirements of federal and state programs responsible for addressing possible safety and environmental risks, carbon storage projects will likely require specific permits. Both DOE and the Regional Partnerships provided comments for the U.S. Environmental Protection Agency's (EPA) first Underground Injection Control program guidance related to permitting initial pilot projects as experimental technology wells, giving regulatory agencies enhanced flexibility in expediting these projects. We are also working closely with the EPA to assess requirements and procedures for permitting future commercial geologic sequestration deployments.

Many of the objectives and activities called for in the Bill are consistent with those of the DOE Sequestration Program including cost-sharing requirements. The Regional Partnerships initiative are investigating small and large-scale tests in each of the seven regions of the partnerships. The Regional Partnerships also contain four Canadian provinces in their area and several Canadian government agencies, thus we anticipate there may be international collaboration in the tests to be conducted in Phase III.

There are a few items in the Bill that may need more clarification. For field validation testing activities, the Bill calls for the Secretary of Energy to promote deep geologic systems that may be used as engineered reservoirs to extract economical quantities of heat. This appears to be utilizing CO_2 as a fluid medium for geothermal power. DOE's Office of Fossil Energy is unaware of the promise of this concept and would need further clarification. Also, the Bill allows the Secretary to 'promulgate policies, procedures, requirements, and guidance to ensure that the objectives are met.' The provision should be clarified to determine if this provides the Secretary with the authority for DOE to undertake liability for large-scale testing should this become an issue that delays or halts large-scale testing. The bill should clarify that any new policies, procedures, requirements, and guidance should support or be consistent with existing environmental and public health statutes, regulations, and policies.

The Administration is working to develop estimates for the Large-Volume Testing for Phase III of the Regional Partnerships, in addition to funding for the base program of R&D in capture. The majority of funding for the large-volume tests would be required in the earlier years for drilling and injection and for infrastructure con-

struction, with lesser amounts later for monitoring and verification. We note that funding beyond the three years of appropriations authorized in the Bill would be required for both the Sequestration Program core activities and the Regional Partnerships.

MOVING TOWARD COMMERCIAL DEPLOYMENT

Carbon capture and storage can play an important role in mitigating carbon dioxide emissions under potential future stabilization scenarios. The United States has a large capacity of geologic formations amenable to CO_2 storage. DOE's Carbon Sequestration Program will continue to move geologic sequestration technology toward readiness for commercial deployment.

Mr. Chairman, and members of the Committee, this completes my prepared statement. I would be happy to answer any questions you may have at this time.

The CHAIRMAN. Well, thank you both for the testimony.

Let me ask a few questions. We'll take 5-minute rounds for questions.

First, Dr. Myers, let me ask you—you say in your testimony that the bill, as currently drafted, doesn't provide enough time for this assessment—for the methodology to be developed and then for the assessment to be done. What are the right periods of time, in your opinion?

Dr. MYERS. Mr. Chairman, it will take about a year to develop a methodology and then to have it peer-reviewed, which, again, is an important, critical part of this part of the process. And then, about 2 to 3 years to do the full national assessment.

The CHAIRMAN. So, 1 year to develop and have peer-reviewed the methodology, and then, what 2 to 3 years after that you would have the actual assessment done? Is that your——

Dr. MYERS. Completed, yes.

The CHAIRMAN. That's your view? Okay.

Mr. Shope, do you think that's realistic as a timeframe for getting these things done?

Mr. SHOPE. Well, I do think that's realistic for the enhancement of the work that we've already undertaken. So, we, at the Department of Energy and through the regional partnerships, are beginning the process now towards these large-scale tests. Where the real data need is going to be for that detailed information is as we move forward with additional large-scale tests with commercialization and deployment of these technologies.

The CHAIRMAN. Well, I think some of the testimony from the second panel deals with this issue of liability, or potential liability if we get into large-scale demonstration projects. Is that something that we need to be worried about here? Do we need to be dealing with that by way of legislating something, in the views of either one of you? Dr. Myers, did you have any thoughts on this?

Dr. MYERS. Mr. Chairman, I'm not an expert on liability, but, I think, in the early stages, the tests are in oil and gas fields. I would suggest that the oil and gas leases would probably have a great deal to say on who has the liability. And then, it would be either a State or a Federal lease. It would depend on that. But I'll defer to better experts on the law.

The CHAIRMAN. Have you looked at this issue, Mr. Shope? Did you have a view?

Mr. SHOPE. We're certainly looking at this issue, Mr. Chairman, and it is a very significant issues. And it is one that this committee needs to be monitoring and working with. Obviously, what goes

hand in glove with the liability are the insurance provisions, and we have had discussions with insurance carriers, and they are, obviously, concerned about—they like to have some definition—fixed, calculable times, and that's not consistent, necessarily, with what we are dealing with over geologic time. So, they are having difficulties in determining what exactly the total risk would be. As my colleague had mentioned, of course, we do have some experience through the enhanced oil recovery, through—in oil fields. That certainly lends itself to additional experience. However, one of the caveats is that the volumes that we are talking about under carbon capture and storage are significantly greater than those that are used in enhanced oil recovery. Furthermore, the utility sector isn't used to dealing with these provisions, as is the oil industry. And we are working, at DOE, of course, with our sister agencies, including the EPA, looking at this.

And I'll further note that there is a movement across the country to deal with this on a State level. Of course, for our FutureGen project we do have concerns about liability, going forward, and both the candidate States of Texas and Illinois are both working with liability provisions. Texas has passed a provision to allow a State to take ownership of the CO_2, and both Texas and Illinois are working on potential indemnification provisions to indemnify the alliance.

So, there is movement afoot, and it is certainly going to be a concern, going forward.

The CHAIRMAN. Well, I think I hear what you're saying, which is that there is movement afoot, but there is nothing concrete that you would recommend we try to legislate, at this point.

Mr. SHOPE. That is correct, Senator. Again, I think a lot of the data that'll come out of these tests that we're talking about today will help guide those decisions.

The CHAIRMAN. Okay. Let me stop with that.

Senator Domenici.

Senator DOMENICI. Thank you, Mr. Chairman, for yielding. And obviously this is going to be a very short day, but I want to make a couple of points, with your permission.

Do you agree with the following statement going forth from this committee to those who are interested in this issue, that are now part of the Government and other agencies or the like, that those other agencies should garner from this hearing that we're not on a short—that we're not on a long-term lease, we're on a short one. If we're going to make any headway with CO_2, we're going to make it as part of a very accelerated plan that's going to go into effect and get carried out rather quickly, and it's not going to do anyone any good to make things difficult or stay out of the processes. They all have to get in and get their 2 cents put before the lead committees so that we'll know where things are.

Is that a fair statement, Mr. Chairman?

The CHAIRMAN. Yes, that certainly is fair. It's my purpose, and, I believe, the purpose of most members of this committee, that we move out as aggressively as we can to persuade the Congress to do so on dealing with this issue and doing these demonstration programs and really determining whether this is a solution for our

problem of capture—for the problem of greenhouse gas emissions from coal-burning operations.

Senator DOMENICI. Thank you, Mr. Chairman. I hope we will note that, and it will be noted.

I do want to ask, with reference to what's going on out there—might I ask—the Duke—the recently released Duke University study states that much of eastern Virginia, all of North Carolina, South Carolina, and Georgia are devoid of potential carbon dioxide sequestration sites. S. 731 calls for a survey of potential carbon dioxide storage sites. What implication does this have for the scale of carbon dioxide infrastructure? Is this scale feasible? Should S. 731 include the analysis of existing pipeline rights-of-way to assess feasibility of this approach? I ask that to either of you.

Dr. MYERS. Senator Domenici, let me just start with a few comments.

One is, the atlas was a great starting product, but there's still a lot of questions, particularly in areas where there's little geologic data at the deeper horizons. And the States you mentioned are States where we do have very little data, particularly understanding the particular reservoir properties that might be down there, the trapping mechanisms that might be available in those States. So, understanding geologic carbon sequestration, the process of doing a full, robust national assessment will lead to an understanding of areas that are more capable than others, but also where the data gaps are and where the uncertainty is—level of uncertainty.

With respect to that, until you've done that study, it's going to be very difficult to talk about how robust the pipeline infrastructure is. If we're going to be shipping significant quantities of CO_2 over a long distance, that's a very large investment, and it has to be capitalized somehow. But, I think, first, understanding the baseline assessment is the first step to better clarifying, then the next economic steps, whether it be transporting it to sites that are more applicable or whether it be using alternative sources of sequestration in those areas.

Mr. SHOPE. I don't have much more to add to that, Senator. Again, I—just following on—of course, it is—all pieces of that puzzle will need to be put into place. The infrastructure is usually an important component.

Senator DOMENICI. That's all I have for now, Senator.

The CHAIRMAN. I would particularly commend Senator Salazar and Bunning, I believe, for being the lead sponsors on this legislation.

Senator Salazar.

Senator SALAZAR. Thank you very much, Senator Bingaman. I appreciate you holding the hearing, and for your leadership on this issue, as well, and for Senator Domenici's leadership on this issue, as well.

I think as we deal with this whole issue of global warming and carbon capture, this is certainly one of the most promising areas as we deal with the reality of having to use coal-burning powerplants, which is going to be a reality here in this country, and at the same time as we deal with the concerns about our environmental security. And I think having the kinds of assessments in

the programs that we're talking about in this particularly legislation is a very important step forward. As I've said in this committee before, I think when we look at coal in this country, you know, we look at it in the same way that Saudi Arabia probably looks at its oil. We are very rich in coal resources. And if we can find ways of burning it and dealing with the environmental security issues, it will not only advance our notion of getting to energy independence, but also help the world—the rest of the world come along with us, including places like China and other places that are burning a lot of coal.

I will note, Mr. Chairman, that it's very interesting, when you look at the endorsements that we have for S. 731, that it comes from a very interesting mix of partners. You have the America Public Power Association, coal companies like Arch Coal and Clean Air Task Force, the Colorado Association of Municipal Utilities, the Colorado Mining Association; but, at the same time, you have the Natural Resources Defense Council, the Massachusetts Institute of Technology, the National Academies, and the list goes on. But certainly, the coalition that is behind the legislation demonstrates the great interest that we have in carbon sequestration as a very promising technology.

I also want to thank Senators Bingaman, Brownback, Bunning, Casey, Lugar, Tester, Webb and others who have been involved in sponsoring this legislation. And I look forward to us being able to move forward with it as soon as we possibly can.

I have two questions, very quickly, here. First, to you, Dr. Myers. You responded, to the question from Senator Bingaman, that you thought that the methodology could be developed within a year, and peer-reviewed within a year, and that the actual assessments then could be completed 2 or 3 years after that. So, we're talking about a timeframe here of 2 to 3 years. Now, those timelines would be timelines that, from a USGS perspective, you think are appropriate ones, the ones that you laid out?

Dr. MYERS. Yes, I do, Senator Salazar. And, again, as my colleague from DOE has pointed out, that this is a collaborative effort, we'd expect the State geologic surveys to be involved, DOE, and other Federal agencies that have data. But you look at the immensity of the United States, and you look at the varying geologic conditions in these sedimentary basins, then the baseline understanding of those—you'll find, in many basins, outside the traditional oil and gas areas, there is very little deeper data on saline reservoirs. There's very little understanding of deeper trapping mechanisms that might be available. So, I think when we look at it realistically, it is a multiyear process, and it needs to be a collaborative effort. So, 2 to 3 years, I believe that we're capable of putting together a first assessment in collaboration with the partners, and I think it would be a good assessment. You would certainly continue to be reassessing, as you've got additional data, as the technology improved, as you were able to narrow down certain issues, as you acquired additional data in some of these key States where there might be a lot of uncertainty. But I think 2—again, about a 3- to 4-year process, in total, to get to the first robust national assessment is appropriate.

Senator SALAZAR. Okay, thank you very much.

And, Secretary Shope, if I can ask you a question on the liability issue. Your response to the earlier questions is that there are States that have moved forward to try to provide some liability protection as we move forward with carbon sequestration projects. Does it seem to you that that's something that we ought to deal with at the national level, as we move forward with these demonstration projects, that we're providing adequate liability protection for those who are taking risk in, sometimes, investing what I understand will be up to billion-dollar kinds of projects to see how carbon sequestration might actually work?

Mr. SHOPE. Thank you, Senator. I know that you will probably hear, later today, from some of the other panelists and partnerships, that, of course that's a huge concern and that we need to be considering the Federal Government taking liability provisions—making those provisions available. At this time, we're not prepared to make that recommendation. Again, I think there is a—a wait-and-see would be appropriate, to some extent, because we want to see how this develops through the country to see—there are regional aspects, and, if it is going to be dealt with sufficiently on the local level, then we wouldn't need to impose a Federal provisions. But it is going to be a huge issue that we need to grapple with as we move forward and gain additional data that will help us make those determinations.

Senator SALAZAR. Thank you very much.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

Senator Thomas.

Senator THOMAS. Thank you, Mr. Chairman.

Thank you, gentlemen, for being with us.

Dr. Myers, you stated in your testimony that USGS does not currently have the experience assessing national capacity of geological sequestration. I was under the impression that USGS had assisted in the Department of Energy's National Carbon Sequestration Atlas, this 90-page document. Can you clarify for the committee the role USGS played in putting that together?

Dr. MYERS. Senator Thomas, many of the baseline levels of data acquired—the coal distribution, the oil and gas field distribution, the reservoir properties, the geologic mapping that went into the assessment—are USGS products, but we were not the lead—and we did have some scientists involved with the regional partnerships—but overall, we were not, again, the major lead, nor was the methodology used the traditional methodology that we would use, or a type of methodology we would use, at the USGS. I believe the compilation is done by NETL. Is that correct? NETL—NETL. So, again, it's a very good first pass, but it——

The CHAIRMAN. Could you clarify what NETL is?

Mr. SHOPE. That's our National Energy Technology Laboratory.

The CHAIRMAN. Okay.

Mr. SHOPE. Pittsburgh, and Morgantown, West Virginia.

The CHAIRMAN. Okay.

Dr. MYERS. And I believe we have the technical expertise to do it, but we're not funded on the level we would need to be to actually perform the baseline work of developing the national assessment.

Senator THOMAS. Not funded. Never heard that before.

[Laughter.]

Senator THOMAS. Mr. Shope, we inject CO_2 in the ground for enhanced oil recovery in my State. I've always been told this is a very safe and efficient process. I've also been told that roughly 60 percent of that injection stays put. There's been a lot of talk about liability with carbon sequestration later; however, is there a reason to be concerned about liability? Is carbon sequestration any different than EOR is, in that respect?

Mr. SHOPE. Senator, we have seen no indications, at this point, that there is a concern for liability. We agree with you, the—it is analogous to enhanced oil recovery. There are, obviously, a few issues that we need to be looking at, and the major one, I probably indicated earlier, is just the sheer volumes of CO_2 that we're dealing with. And in this country, I believe the figure is about 35 million tons of CO_2 that were used for enhanced oil recovery. The amount of CO_2 that we would be injecting from full-scale deployment would be vastly greater than that, orders of magnitude higher.

Senator THOMAS. Yes.

Mr. SHOPE. So, that would be the concern, Senator.

Senator THOMAS. It's been said that DOE regional partnerships do not have the manpower necessary to acquire data for mapping the storage capacity. I think we need to get on with seeing if sequestration actually works the way some people envision. Is the comprehensive mapping of CO_2 strategy capacity prerequisite to conducting small number of demonstration projects?

Mr. SHOPE. It is not. We are currently undergoing those projects. We are beginning with the rollout of 25 projects, smaller-scale projects throughout the country, leading towards large-scale projects, as I testified to, which will begin, here. The processing of those will begin this fiscal year. I think where the database would come in handy, again, is to enhance and refine those figures as we move forward. We have the information we need today to do those small-scale tests, but, as we move forward towards large-scale deployment and commercialization, that information would be crucial.

Senator THOMAS. Well, I'm sure you're aware, given your work on fossil fuel energy, supply of money for research is not an endless one. If you had to choose between conducting a comprehensive mapping capacity or using the information that you already have to conduct some commercial-scale demonstrations, which would you choose?

Mr. SHOPE. That's not a fair question to ask of us, Senator.

[Laughter.]

Senator THOMAS. I think so. Sometimes we get so taken up with all the research and the mapping, when we already know how to do some of these things, and we could be doing it, as opposed to years and years of research. We can't do anything for 4 years.

Mr. SHOPE. I would encourage you, again, Senator, to note that we are moving forward on this testing, we are moving forward with the small-scale tests, and the large-scale tests are coming forward. We have the information that we need, to conduct those tests and move out, and we are doing that.

Senator THOMAS. Okay, Thank you.

The CHAIRMAN. Senator Bunning.

Senator BUNNING. Thank you, Mr. Chairman.

Mr. Shope, in your testimony you said DOE's budget for sequestration is $86 million in fiscal year 2008. Is that correct?

Mr. SHOPE. That's correct.

Senator BUNNING. On the budget resolution, Senator Obama and I introduced an amendment, cosponsored by the chairman of this committee, to provide $200 million for the DOE to conduct carbon capture and sequestration demonstrations. This, too, is only a start. Could you discuss your funding needs for these demonstration programs in the long term?

Mr. SHOPE. I will address that, Senator. And this relates, also, to Senator Thomas's remarks, and that is, this is not an inexpensive proposition. These tests will be expensive, going forward. And one only need to look at the current price for—commodity price for CO_2, at $20 a ton, on average, a million tons a year, you're looking at $20 million for 1 year of injection for a 1-million-ton project, per year. That adds up. Our budget is sufficient to go forward in 2007 and 2008. We have a total of 180 million over those 2 years to begin these small-scale tests and to begin the large-scale testing. Going forward, we're working on our figures for—right now, for 2009 and beyond. But your comments are well taken, that this is going to require sufficient—a large amount of funding.

Senator BUNNING. But you can't put a number on it in the long term?

Mr. SHOPE. Senator, we're working on those figures for our 2009 budget proposal, at this time.

Senator BUNNING. Would you agree or disagree with the amendment that—in other words, the administration doesn't particularly care for the amendment that went on, the additional money for DOE?

Mr. SHOPE. I—the money that we have in a—President's request is sufficient to move forward with what—with the tests that we are undertaking in 2007 and 2008. So, we are moving out on those tests, and we have sufficient funds to begin those tests.

Senator BUNNING. You mentioned the cost of buying CO_2 on the market. How does the DOE intend to buy this carbon? Would it make any sense to pair your regional test sites with an industrial source like a coal-to-liquids plant that can provide you with the millions of tons of CO_2 you will need?

Mr. SHOPE. Absolutely. That's a concern, Senator. We do not want to impact the existing market for CO_2. We need to be very cognizant of that fact. We will be receiving back from the partnerships their proposals to do these large-scale tests, going forward. So, we're going to receive those later this summer. I think the partnerships are struggling with that very issue right now, to figure out where can we get the CO_2 to do these large-scale tests?

Senator BUNNING. Okay. This is my last question for you. While I have cosponsored both the USGS and the DOE legislation, because I believe they are both important projects, how can we be certain that we do not duplicate our efforts? Are there changes we need to make to these two bills to ensure that the USGS and the DOE work together?

Mr. SHOPE. We are ready, willing, and able to work together with our colleagues and benefit from their expertise in the USGS, and we will do it.

Senator BUNNING. Well, you didn't answer my question.

Mr. SHOPE. No, there is nothing that—I don't think there is any further revision that needs to be made to the bill, Senator.

Senator BUNNING. In other words, we can pass them, as they're presently structured.

Mr. SHOPE. With respect to that—to the collaboration-and-coordination issue, that's correct.

Senator BUNNING. All right, thank you, Mr. Chairman.

The CHAIRMAN. Senator Corker.

Senator CORKER. Thank you, Mr. Chairman, and for your leadership and for your testimony.

As part of the braintrust, if you will, that exists around carbon capture and sequestration, we've had a lot of unintended consequences, I guess, as a world, around CO_2 emissions, something that we didn't know existed—you couldn't see it, you couldn't smell it, you didn't know it was happening. Do you know, are there any concerns in your Departments, or other places that you deal with, unintended consequences that might occur by putting CO_2 back into the ground in this magnitude? I know we've done it in a much, much, much smaller way in oil recovery, but when scientists are sitting around talking, are there any unintended consequences for the whole world, if you will, to end up pumping this much CO_2 into our core?

Dr. MYERS. Senator, I think, again, if you look at the two bills, and you look at the concurrences of the agencies, we're in the infancy of really understanding the full-scale effects and the full-scale capability to be able to geologically sequester carbon. Because the scale's—it's fairly straightforward to look at the issue with respect to an oil and gas field, where you have a lot of data, you know, where you have a tripping mechanism, on a geological scale. But when you get beyond those areas that have, sort of, the low-hanging fruit, the good datasets, you get to the areas of—if you inject it into saline aquifer, you know, at the scale we're talking about, what are the trapping mechanisms like, what are the geochemical reactions in the reservoir that change things? If you inject into coal seams, what—when they absorb into the coal seams, what are you releasing into the coal seam? Lots of questions on national capacity. In saline aquifers, how far—an oil and gas accumulation is a distinct accumulation, where you have oil unusually underlaying by water—that water lake may be a perfectly good place to inject CO_2, but you don't know, necessarily, where the down-dip sealing end of that oil and gas field is. So, again, the capacity question comes up. What data do you need, to assure that you have sufficient capacity in that reservoir? And then, the length of time that you need to store it, you know, what is the national agenda? Is it 100 years? Is it 1,000 years? So, different reservoirs will transmit gases at different speeds. So, you have to look, again, and put some careful qualifications on what you're trying to accomplish. Then you have to develop a methodology for monitoring to make sure that those reservoirs where you're storing it, in fact, are sealing and stable.

So, there's a lot of work that needs to be done. I think, again, these bills are recognitions of that, recognitions of what, the administration knows, needs to be a tremendous amount of scientific and engineering work that—to advance it to the point we can really understand the large-scale commercial impacts of it.

Thank you.

Mr. SHOPE. And I would just add, to Dr. Myers' comments, that if you look at our program that the regional carbon sequestration partnerships are doing, the 25 tests are geared to address those issues. We've specifically designed the tests to be done in different geological formations in different locations to get at those very questions: the permanence, the migration. All of those issues are part of our suite of tests.

Senator CORKER. We spend a lot of time in our offices just looking at the various technologies and certainly understanding, you know, trying to understand things that are taking place right now that are going to help us. For instance, with alternative cellulose, how big a player that's actually going to be. And most of the people that talk with us give us time horizons as to when they think we'll be at full scale using those types of things. Obviously, for us to use clean coal technologies, what you're doing, at some point, has to be at full-scale operations. And for someone who's not been around the oil producing States, if you will, it's hard for me to imagine—it's really hard for me to imagine this being a cost-effective way of dealing with carbon. I'm supporting these bills, and certainly hope that that's going to be the case. But since you are so close to it, can you give me a—just sort of a gut feel as to when you think our country—because we're going to be passing other pieces of legislation that need to dovetail with this—when our country will be at a position where we'll actually be at a full-scale level, capturing carbon, sequestering carbon, and taking into account some of the geographical issues that we have to deal with, where, you know, some States just don't have, underneath them, the ability to store? I'd just love to have a—sort of a horizon when you think this is going to be something we're really using full scale in our country.

Mr. SHOPE. Thank you for the question, Senator; and it's an excellent one, because when you look at the storage components which we're dealing with today in these bills, predominantly, really it's only one piece of the larger puzzle. We need to bring along the capture technologies as fast, if not faster, than the sequestration-and-storage technologies, as well, so that once we have developed these wonderful sinks to put carbon dioxide into, as we addressed earlier with Senator Bunning and Senator Thomas, that there is, in fact—the CO_2 can be captured and put into those storage facilities.

Our program is geared towards accomplishing that goal. If under current budget constraints and outlooks, we would be looking at these technologies available—the storage technologies to be available in the post-2012 timeframe. That means they're available. If we have—first commercial deployment of same puts you into the 2020 timeframe for wide-scale large technology of choice; that is, that the current—the powerplant off-the-shelf technology includes a FutureGen-esque plant of carbon capture, storage, and—long

term storage, you're looking at in the 2045 timeframe for large-scale deployment of that.

So, those technologies will be available, and will be deployable, in the 2020 to 2025 timeframe, but, again, we're not going to see common, everyday deployment of that until approximately 2045.

Senator CORKER. Thank you.

Thank you very much.

The CHAIRMAN. Let me just advise members that I didn't plan to have any more questions of this panel. So, unless members have some burning desire to ask more questions we have another panel of three witnesses that we need to get to.

Thank you both very much for your testimony, and I'll ask the second panel to please come forward so we can hear their testimony.

Senator DOMENICI. Senator Bingaman.

The CHAIRMAN. Yes?

Senator DOMENICI. While the panel is assuming their positions, might I, for the record, just raise an issue and discuss it with you?

First of all, it would appear, based upon the questions that have been lodged to the first witnesses, that the Department is moving along as expeditiously as possible, and they are telling us, here today, what we must do for that expeditious moving to reach a point where we will, in fact, be able to move ahead with what must be done with the CO_2 in order to have a real program for our country.

I wanted to express, on behalf of myself, and hopefully with your concurrence, the positive nature of a compliment to the Department, the Department's people, for moving along as expeditiously as they have. I think it's imperative that we do. And I think they have. And also, for those who are working with the Department that we have heard from by way of outside consultants and the like, I think that's good for the country and good for us, and I think we are showing the country that we're not here to lallygag, but, rather, to move with dispatch.

I compliment you for that. We could have put this over from late this afternoon to another day, as is the tendency, but you wanted to do it, as you usually do, when it could be done, even if it was Friday afternoon—wanted to get it done, and I commend you and hope that we can get it done today and get ready.

When we hear these witnesses, we will be ready to go, and I commend our staff to move with dispatch thereafter.

Thank you, Mr. Chairman.

The CHAIRMAN. Well, I certainly agree that we need to move ahead with these two bills, and then we need to figure out what else can be done to accelerate the process. Obviously, the timeframes that Mr. Shope was indicating are problematic, from my perspective; they're way too long, when you're talking about how long it would take to actually get to large-scale demonstration of carbon capture and storage. But I hope we can speed those up.

This second panel: Dr. George Guthrie is program director for fossil energy and environment at Los Alamos National Laboratory—thank you for being here, Dr. Guthrie; Dr. David Hawkins, who's a frequent testifier before our committee, is director of Climate Center for the Natural Resources Defense Council; and Mr.

Kipp Coddington is a partner with Alston & Bird, here in Washington. Thank you all very much for being here.

Unless you have some preference otherwise, why don't you start, Dr. Guthrie, and we'll just go across the table, as we did with the previous panel.

STATEMENT OF DR. GEORGE GUTHRIE, PROGRAM DIRECTOR, FOSSIL ENERGY AND ENVIRONMENT PROGRAMS, LOS ALAMOS NATIONAL LABORATORY

Dr. GUTHRIE. Chairman Bingaman, Senator Domenici, and members of the committee, thank you for the opportunity to provide testimony regarding the legislation on the capture and geologic storage of carbon dioxide.

My name is George Guthrie. I'm a geochemist, and I've worked, over 10 years, on various aspects of CO_2. I'm currently program director for fossil energy and environment programs at Los Alamos.

As you know, fossil fuels are central to the global energy portfolio, and they're likely to remain so for at least decades. Geologic sequestration of carbon dioxide offers great global potential to manage the carbon emissions for fossil fuels.

We already have experience dealing with some aspects of geologic sequestration. The United States leads the world in the technology of CO_2 injection to recover oil from depleted oil reservoirs—a process known as enhanced oil recovery, or EOR. Power-plant scale volumes of CO_2 have been handled, transported, and injected into geologic reservoirs for more than 30 years as part of EOR operations, primarily in the Permian basin of west Texas. More recently international efforts include the Weyburn project in Canada and the Sleipner project in Norway, both of which involve large-scale CO_2 injection.

From this experience base, we know that we can handle and inject CO_2 volumes equivalent to the output of powerplants. So, what questions remain to be addressed? Well, first, large-scale capture of CO_2 at powerplants must be developed and understood. Second, our storage capacity estimates must be improved by detailed geologic studies. Third, large-scale injection must be demonstrated under the variety of conditions that we anticipate for sequestration. And, finally, we need to verify the long-term safety and reliability of storage sites, which will require a robust risk-assessment framework.

Each of these issues is important, but in my remaining time, I'd like to elaborate on risk assessment, which was called out in both pieces of legislation.

Risk assessment is particularly challenging due to the implementation scale, both in terms of the volumes of CO_2 involved and in terms of the timescales necessary for effective storage. Consequently, risk assessments must be science-based.

Some of the scientific base can come from laboratory experiments and theoretic studies; however, large-scale field studies are the only option for some of the essential data. These sites fall into two broad categories. This includes large-scale injection demonstrations and analog sites, which includes large natural accumulations of CO_2 and industrial sites like EOR operations.

Analog sites provide information on long-term conditions and long-term concerns, namely those that pertain to the fate and impact of CO_2. Wellbores are an excellent example of this. They're a critical component of the containment system, they're required to place the buoyant CO_2 below an impermeable barrier. The problem is that wellbores use cement that may degrade when exposed to CO_2 and water.

As part of our support for DOE's carbon sequestration program, we recently completed the first field-based study of this issue using samples from a mature EOR site. The result showed that interactions do occur, but complete degradation may not be an issue for some geological environments. In fact, in some cases, beneficial reactions may actually occur that improve the integrity of the wellbore. We need more studies on wellbores, but these results demonstrate the importance of field observations in developing a reliable risk-assessment framework.

Some data for risk assessment must be collected from large demonstration projects. Consider the impacts associated with the injection of CO_2 storage operation. In EOR, CO_2 is injected into a reservoir, where fluids have been, and continue to be, removed. In contrast, a storage operation might involve situations where CO_2 is used to displace pre-existing reservoir fluids, and this creates different physical conditions. Large-scale demonstration projects from a wider range of geological environments are critical to address issues like these that are unique to CO_2 storage.

In closing, I want to emphasize that moving forward with carbon sequestration research is a positive step for the Nation. We are at a point where many of the remaining questions can only be answered by larger field efforts. We know we can handle and inject CO_2 safely at large volumes, but we need to show that CO_2 capture at powerplants works; we need to improve our estimates on the overall storage capacity for geologic storage, and we need to develop the confidence that CO_2 storage is a safe and effective option for the long term.

The proposed work in the legislation is critical in moving geologic sequestration forward from a good concept to a meaningful option.

The CHAIRMAN. Thank you very much.

Mr. Hawkins.

STATEMENT OF DAVID G. HAWKINS, DIRECTOR, CLIMATE CENTER, NATURAL RESOURCES DEFENSE COUNCIL

Mr. HAWKINS. Thank you very much, Senator. And I appreciate the promotion to "Doctor," but I'm just a recovering lawyer.

[Laughter.]

Mr. HAWKINS. I direct the Climate Center at Natural Resources Defense Council, and it's a pleasure to be here again before the committee.

NRDC supports the work that's called for in S. 731 and S. 962, and we congratulate the lead sponsors and other sponsors for introducing this. Why is that? Well, because coal is so abundant, and because coal plants continue to be built around the world, capture of carbon dioxide and geologic disposal, we think, is essential to avoid profoundly damaging disruption of our climate.

Just one scary anecdote. New coal plants that are forecast to be built in the next 25 years, if they are not equipped with CO_2 capture equipment, during their lifetime they will emit CO_2 in an amount that is 30 percent more than all of the CO_2 released from all previous human use of coal. And that's associated with just 25 years of investment. That's a phenomenal commitment, a phenomenal mortgage on the future of our planet's climate if we don't do something. Therefore, we cannot afford to delay the use of carbon capture and disposal on these new coal plants.

So, what do we know? Well, we know enough now to get started, but more rigorous information of the kind that will be provided by this legislation is important. And we also need rules of the road. Rules of the road can be provided by EPA. EPA has legal authority to write such rules, but they don't appear to be hurrying to do it. And we think they should be given direction by this Congress, and we hope that this committee will work with the appropriate committees in Congress to make sure that that does happen.

But I want to stress that policies to limit CO_2 emissions are essential. We can have all the information in the world about the viability of carbon capture and disposal, but it isn't going to be deployed in the real world if there are no policies to limit CO_2 emissions. If we want these technology to advance, and we want them to be deployed in any kind of a meaningful timeframe—and we certainly want them to be deployed before 2045—we're going to need policies to stimulate that. Without those policies, you're going to hear, 10 years from now from the Department of Energy, that it'll be 2055. So, we need that.

But, that said, the policies and practices that are supported by S. 731 and S. 962 are important, because they would provide government support for comprehensive surveys, which are valuable, and initial large-scale injection projects. These things can help speed deployment and build confidence, in the industrial community and in the public, that these—that this is a workable part of the climate policy toolbox.

In S. 962—just several different comments on the bills—we support the fact that financing under the Energy Policy Act of 2005 should now be focused much more on actual carbon capture and disposal. That is what—that's where the payoff is, and that's where the financial incentives ought to be focused.

A couple of additional items. We think that the bill would be improved if it specified that DOE, in consultation with EPA, would set minimum criteria for data collection. What kind of data should be collected from these projects? Let's get some minimum criteria out there so that all seven of these projects are collecting comparable kinds of data. Second, we think that the data collection requirements, as an example, should include assessment of risks and assessment of—and identification of hazards, various leakage pathways. We need to know, from these different sites, what the characterization of that is. Third, we think that DOE, in coordination with EPA, should carry out an integrated assessment of the results of these projects. And I would just say, with respect to the USGS program in S. 731, this is important, because these CO_2 repositories are a natural resources, just as much as a national resource,

just as much as oil and gas resources are, and they ought to be the subject of a national objective assessment.

But, in answer to Senator Thomas's question, we do not need to delay these large-scale demonstration projects to await that comprehensive national database. The national database will be important for later on as we move to scale, but we can move forward with these large projects now, and we urge the enactment of both of these pieces of legislation. We'd be happy to work with the Committee on some suggested improvements.

Thank you very much.

[The prepared statement of Mr. Hawkins follows:]

PREPARED STATEMENT OF DAVID G. HAWKINS, DIRECTOR, CLIMATE CENTER, NATURAL RESOURCES DEFENSE COUNCIL

SUMMARY

Coal use today is responsible for large and mostly avoidable damages to human health and our water and land. Coal use in the future, along with other fossil fuels, threatens to wreak havoc with the earth's climate system. Because coal is so abundant, capture of carbon dioxide from industrial coal sources and geologic disposal (CCD) is essential to reconcile continued coal use with avoidance of this profoundly damaging disruption of our climate. New coal plants forecast to be built in the next 25 years, if not equipped with CCD, will emit 30 per cent more carbon dioxide in their operating lives than has been released from all prior human use of coal. We cannot afford to delay use of CCD on new coal plants.

Fortunately, we know enough today to implement large scale CCD for coal plants now in the design stages. Experts have concluded that such operations can be conducted safely if an effective regulatory regime is put in place to license and monitor operations of disposal sites and that properly selected and operated disposal sites can retain injected CO_2 for the required long periods of time. EPA has the legal authority to write such rules but direction from Congress is needed to assure the rules will be written in a timely manner.

Policies to limit CO_2 emissions and set performance standards are essential to drive use of CCD at the required scale and pace. Such policies should be enacted in this Congress. Well designed measures can phase in CCD on new coal plants with only very modest impacts on retail electricity prices. Government support of initial large-scale injection projects can help speed deployment and build confidence.

Finally, CCD is only one of several tools available to cut global warming emissions. The fastest and cheapest method remains energy efficiency, with increased reliance on renewable energy resources providing another essential tool.

TESTIMONY

Thank you for the opportunity to testify today on S. 731, the National Carbon Dioxide Storage Capacity Assessment Act of 2007 and S. 962, the Department of Energy Carbon Capture and Storage Research, Development, and Demonstration Act of 2007. Both of these bills address important aspects of carbon capture and sequestration. My name is David Hawkins. I am director of the Climate Center at the Natural Resources Defense Council (NRDC). NRDC is a national, nonprofit organization of scientists, lawyers and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has more than 1.2 million members and online activists nationwide, served from offices in New York, Washington, Los Angeles and San Francisco, Chicago and Beijing.

Today, the U.S. and other developed nations around the world run their economies largely with industrial sources powered by fossil fuel and those sources release billions of tons of carbon dioxide (CO_2) into the atmosphere every year. There is national and global interest today in capturing that CO_2 for disposal or sequestration to prevent its release to the atmosphere. To distinguish this industrial capture system from removal of atmospheric CO_2 by soils and vegetation, I will refer to the industrial system as carbon capture and disposal or CCD.

The interest in CCD stems from a few basic facts. We now recognize that CO_2 emissions from use of fossil fuel result in increased atmospheric concentrations of CO_2, which along with other so-called greenhouse gases, trap heat, leading to an increase in temperatures, regionally and globally. These increased temperatures alter the energy balance of the planet and thus our climate, which is simply nature's way

of managing energy flows. Documented changes in climate today along with those forecasted for the next decades, are predicted to inflict large and growing damage to human health, economic well-being, and natural ecosystems.

Coal is the most abundant fossil fuel and is distributed broadly across the world. It has fueled the rise of industrial economies in Europe and the U.S. in the past two centuries and is fueling the rise of Asian economies today. Because of its abundance, coal is cheap and that makes it attractive to use in large quantities if we ignore the harm it causes. However, per unit of energy delivered, coal today is a bigger global warming polluter than any other fuel: double that of natural gas; 50 per cent more than oil; and, of course, enormously more polluting than renewable energy, energy efficiency, and, more controversially, nuclear power. To reduce coal's contribution to global warming, we must deploy and improve systems that will keep the carbon in coal out of the atmosphere, specifically systems that capture carbon dioxide (CO_2) from coal-fired power plants and other industrial sources for safe and effective disposal in geologic formations.

THE TOLL FROM COAL

Before turning to the status of CCD let me say a few words about coal use generally. The role of coal now and in the future is controversial due to the damages its production and use inflict today and skepticism that those damages can or will be reduced to a point where we should continue to rely on it as a mainstay of industrial economies. Coal is cheap and abundant compared to oil and natural gas. But the toll from coal as it is used today is enormous. From mining deaths and illness and devastated mountains and streams from practices like mountain top removal mining, to accidents at coal train crossings, to air emissions of acidic, toxic, and heat-trapping pollution from coal combustion, to water pollution from coal mining and combustion wastes, the conventional coal fuel cycle is among the most environmentally destructive activities on earth. Certain coal production processes are inherently harmful and while our society has the capacity to reduce many of today's damages, to date, we have not done so adequately nor have we committed to doing so. These failures have created well-justified opposition by many people to continued or increased dependence on coal to meet our energy needs.

Our progress of reducing harms from mining, transport, and use of coal has been frustratingly slow and an enormous amount remains to be done. Today mountain tops in Appalachia are destroyed to get at the coal underneath and rocks, soil, debris, and waste products are dumped into valleys and streams, destroying them as well. Waste impoundments loom above communities (including, in one particularly egregious case, above an elementary school) and thousands of miles of streams are polluted. In other areas surface mine reclamation is incomplete, inadequately performed and poorly supervised due to regulatory gaps and poorly funded regulatory agencies.

In the area of air pollution, although we have technologies to dramatically cut conventional pollutants from coal-fired power plants, in 2004 only one-third of U.S. coal capacity was equipped with scrubbers for sulfur dioxide control and even less capacity applied selective catalytic reduction (SCR) for nitrogen oxides control. And under the administration's so-called CAR rule, even in 2020 nearly 30 per cent of coal capacity will still not employ scrubbers and nearly 45 per cent will lack SCR equipment. Moreover, because this administration has deliberately refused to require use of available highly effective control technologies for the brain poison mercury, we will suffer decades more of cumulative dumping of this toxin into the air at rates several times higher than is necessary or than faithful implementation of the Clean Air Act would achieve. Finally, there are no controls in place for CO_2, the global warming pollutant emitted by the more than 330,000 megawatts of coal-fired plants; nor are there any CO_2 control requirements adopted today for old or new plants save in California.

Mr. Chairman and members of the committee, I know the environmental community is criticized in some quarters for our generally negative view regarding coal as an energy resource. But I would ask you to consider the reasons for this. Our community reacts to the facts on the ground and those facts are far from what they should be if coal is to play a role as a responsible part of the 21st century energy mix. Rather than simply decrying the attitudes of those who question whether using large amounts of coal can and will be carried out in a responsible manner, the coal industry in particular should support policies to correct today's abuses and then implement those reforms. Were the industry to do this, there would be real reasons for my community and other critics of coal to consider whether their positions should be reconsidered.

THE NEED FOR CCD

Turning to CCD, my organization supports rapid deployment of such capture and disposal systems for sources using coal. Such support is not a statement about how dependent the U.S. or the world should be on coal and for how long. Any significant additional use of coal that vents its CO_2 to the air is fundamentally in conflict with the need to keep atmospheric concentrations of CO_2 from rising to levels that will produce dangerous disruption of the climate system. Given that an immediate world-wide halt to coal use is not plausible, analysts and advocates with a broad range of views on coal's role should be able to agree that, if it is safe and effective, CCD should be rapidly deployed to minimize CO_2 emissions from the coal that we do use.

Today coal use and climate protection are on a collision course. Without rapid deployment of CCD systems, that collision will occur quickly and with spectacularly bad results. The very attribute of coal that has made it so attractive—its abundance—magnifies the problem we face and requires us to act now, not a decade from now. Until now, coal's abundance has been an economic boon. But today, coal's abundance, absent corrective action, is more bane than boon.

Since the dawn of the industrial age, human use of coal has released about 150 billion metric tons of carbon into the atmosphere—about half the total carbon emissions due to fossil fuel use in human history. But that contribution is the tip of the carbon iceberg. Another 4 trillion metric tons of carbon are contained in the remaining global coal resources. That is a carbon pool nearly seven times greater than the amount in our pre-industrial atmosphere. Using that coal without capturing and disposing of its carbon means a climate catastrophe.

And the die is being cast for that catastrophe today, not decades from now. Decisions being made today in corporate board rooms, government ministries, and congressional hearing rooms are determining how the next coal-fired power plants will be designed and operated. Power plant investments are enormous in scale, more than $1 billion per plant, and plants built today will operate for 60 years or more. The International Energy Agency (IEA) forecasts that more than $5 trillion will be spent globally on new power plants in the next 25 years. Under MA's forecasts, over 1800 gigawatts (GW) of new coal plants will be built between now and 2030—capacity equivalent to 3000 large coal plants, or an average of ten new coal plants every month for the next quarter century. This new capacity amounts to 1.5 times the total of all the coal plants operating in the world today.

The astounding fact is that under MA's forecast, 7 out of every 10 coal plants that will be operating in 2030 don't exist today. That fact presents a huge opportunity—many of these coal plants will not need to be built if we invest more in efficiency; additional numbers of these coal plants can be replaced with clean, renewable alternative power sources; and for the remainder, we can build them to capture their CO_2, instead of building them the way our grandfathers built them.

If we decide to do it, the world could build and operate new coal plants so that their CO_2 is returned to the ground rather than polluting the atmosphere. But we are losing that opportunity with every month of delay-10 coal plants were built the old-fashioned way last month somewhere in the world and 10 more old-style plants will be built this month, and the next and the next. Worse still, with current policies in place, none of the 3000 new plants projected by TEA are likely to capture their CO_2.

Each new coal plant that is built carries with it a huge stream of CO_2 emissions that will likely flow for the life of the plant-60 years or more. Suggestions that such plants might be equipped with CO_2 capture devices later in life might come true but there is little reason to count on it. As I will discuss further in a moment, while commercial technologies exist for pre-combustion capture from gasification-based power plants, most new plants are not using gasification designs and the few that are, are not incorporating capture systems. Installing capture equipment at these new plants after the fact is implausible for traditional coal plant designs and expensive for gasification processes.

If all 3000 of the next wave of coal plants are built with no CO_2 controls, their lifetime emissions will impose an enormous pollution lien on our children and grandchildren. Over a projected 60-year life these plants would likely emit 750 billion tons of CO_2, a total, from just 25 years of investment decisions, that is 30% greater than the total CO_2 emissions from all previous human use of coal. Once emitted, this CO_2 pollution load remains in the atmosphere for centuries. Half of the CO_2 emitted during World War I remains in the atmosphere today.

In short, we face an onrushing train of new coal plants with impacts that must be diverted without delay. What can the U.S. do to help? The U.S. is forecasted to build nearly 300 of these coal plants, according to reports and forecasts published

by the U.S. EIA. We should adopt a national policy that new coal plants be required to employ CCD without delay. By taking action ourselves, we can speed the deployment of CCD here at home and set an example of leadership. That leadership will bring us economic rewards in the new business opportunities it creates here and abroad and it will speed engagement by critical countries like China and India.

To date our efforts have been limited to funding research, development, and limited demonstrations. Such funding can help in this effort if it is wisely invested. But government subsidies—which are what we are talking about—cannot substitute for the driver that a real market for low-carbon goods and services provides. That market will be created only when requirements to limit CO_2 emissions are adopted. This year in Congress serious attention is finally being directed to enactment of such measures and we welcome your announcement that you intend to play a leadership role in this effort.

KEY QUESTIONS ABOUT CCD

I started studying CCD in detail ten years ago and the questions I had then are those asked today by people new to the subject. Do reliable systems exist to capture CO_2 from power plants and other industrial sources? Where can we put CO_2 after we have captured it? Will the CO_2 stay where we put it or will it leak? How much disposal capacity is there? Are CCD systems "affordable"? To answer these questions, the Intergovernmental Panel on Climate Change (IPCC) decided four years ago to prepare a special report on the subject. That report was issued in September 2005 as the IPCC Special Report on Carbon Dioxide Capture and Storage. I was privileged to serve as a review editor for the report's chapter on geologic storage of CO_2.

CO_2 CAPTURE

The IPCC special report groups capture or separation of CO_2 from industrial gases into four categories: post-combustion; pre-combustion; oxyfuel combustion; and industrial separation. I will say a few words about the basics and status of each of these approaches. In a conventional pulverized coal power plant, the coal is combusted using normal air at atmospheric pressures. This combustion process produces a large volume of exhaust gas that contains CO_2 in large amounts but in low concentrations and low pressures. Commercial post-combustion systems exist to capture CO_2 from such exhaust gases using chemical "stripping" compounds and they have been applied to very small portions of flue gases (tens of thousands of tons from plants that emit several million tons of CO_2 annually) from a few coal-fired power plants in the U.S. that sell the captured CO_2 to the food and beverage industry. However, industry analysts state that today's systems, based on publicly available information, involve much higher costs and energy penalties than the principal demonstrated alternative, pre-combustion capture.

New and potentially less expensive post-combustion concepts have been evaluated in laboratory tests and some, like ammonia-based capture systems, are scheduled for small pilot-scale tests in the next few years. Under normal industrial development scenarios, if successful such pilot tests would be followed by larger demonstration tests and then by commercial-scale tests. These and other approaches should continue to be explored. However, unless accelerated by a combination of policies, subsidies, and willingness to take increased technical risks, such a development program could take one or two decades before post-combustion systems would be accepted for broad commercial application.

Pre-combustion capture is applied to coal conversion processes that gasify coal rather than combust it in air. In the oxygen-blown gasification process coal is heated under pressure with a mixture of pure oxygen, producing an energy-rich gas stream consisting mostly of hydrogen and carbon monoxide. Coal gasification is widely used in industrial processes, such as ammonia and fertilizer production around the world. Hundreds of such industrial gasifiers are in operation today. In power generation applications as practiced today this "syngas" stream is cleaned of impurities and then burned in a combustion turbine to make electricity in a process known as Integrated Gasification Combined Cycle or IGCC. In the power generation business, IGCC is a relatively recent development—about two decades old and is still not widely deployed. There are two IGCC power-only plants operating in the U.S. today and about 14 commercial IGCC plants are operating, with most of the capacity in Europe. In early years of operation for power applications a number of IGCC projects encountered availability problems but those issues appear to be resolved today, with Tampa Electric Company reporting that its IGCC plant in Florida is the most dispatched and most economic unit in its generating system.

Commercially demonstrated systems for pre-combustion capture from the coal gasification process involve treating the syngas to form a mixture of hydrogen and CO_2 and then separating the CO_2, primarily through the use of solvents. These same techniques are used in industrial plants to separate CO_2 from natural gas and to make chemicals such as ammonia out of gasified coal. However, because CO_2 can be released to the air in unlimited amounts under today's laws, except in niche applications, even plants that separate CO_2 do not capture it; rather they release it to the atmosphere. Notable exceptions include the Dakota Gasification Company plant in Beulah, North Dakota, which captures and pipelines more than one million tons of CO_2 per year from its lignite gasification plant to an oil field in Saskatchewan, and ExxonMobil's Shute Creek natural gas processing plant in Wyoming, which strips CO_2 from sour gas and pipelines several million tons per year to oil fields in Colorado and Wyoming.

Today's pre-combustion capture approach is not applicable to the installed base of conventional pulverized coal in the U.S. and elsewhere. However, it is ready today for use with IGCC power plants. The oil giant BP has announced an IGCC project with pre-combustion CO_2 capture at its refinery in Carson, California. When operational the project will gasify petroleum coke, a solid fuel that resembles coal more than petroleum to make electricity for sale to the grid. The captured CO_2 will be sold to an oil field operator in California to enhance oil recovery. The principal obstacle for broad application of pre-combustion capture to new power plants is not technical, it is economic: under today's laws it is cheaper to release CO_2 to the air rather than capturing it. Enacting laws to limit CO_2 can change this situation, as I discuss later.

While pre-combustion capture from IGCC plants is the approach that is ready today for commercial application, it is not the only method for CO_2 capture that may emerge if laws creating a market for CO_2 capture are adopted. I have previously mentioned post-combustion techniques now being explored. Another approach, known as oxyfuel combustion, is also in the early stages of research and development. In the oxyfuel process, coal is burned in oxygen rather than air and the exhaust gases are recycled to build up CO_2 concentrations to a point where separation at reasonable cost and energy penalties may be feasible. Small scale pilot studies for oxyfuel processes have been announced. As with post-combustion processes, absent an accelerated effort to leapfrog the normal commercialization process, it could be one or two decades before such systems might begin to be deployed broadly in commercial application.

Given, the massive amount of new coal capacity scheduled for construction in the next two decades, we cannot afford to wait until we see if these alternative capture systems prove out, nor do we need to. Coal plants in the design process today can employ proven IGCC and precombustion capture systems to reduce their CO_2 emissions by about 90 percent. Adoption of policies that set a CO_2 performance standard now for such new plants will not anoint IGCC as the technological winner since alternative approaches can be employed when they are ready. If the alternatives prove superior to IGCC and pre-combustion capture, the market will reward them accordingly. As I will discuss later, adoption of CO_2 performance standards is a critical step to improve today's capture methods and to stimulate development of competing systems.

I would like to say a few words about so-called "capture-ready" or "capture-capable" coal plants. I will admit that some years ago I was under the impression that some technologies like IGCC, initially built without capture equipment could be properly called "capture-ready." However, the implications of the rapid build-out of new coal plants for global warming and many conversations with engineers since then have educated me to a different view. An IGCC unit built without capture equipment can be equipped later with such equipment and at much lower cost than attempting to retrofit a conventional pulverized coal plant with today's demonstrated post-combustion systems. However, the costs and engineering reconfigurations of such an approach are substantial. More importantly, we need to begin capturing CO_2 from new coal plants without delay in order to keep global warming from becoming a potentially runaway problem. Given the pace of new coal investments in the U.S. and globally, we simply do not have the time to build a coal plant today and think about capturing its CO_2 down the road.

Implementation of the Energy Policy Act of 2005 approach to this topic needs a review in my opinion. The Act provides significant subsidies for coal plants that do not actually capture their CO_2 but rather merely have carbon "capture capability." While the Act limits this term to plants using gasification processes, it is not being implemented in a manner that provides a meaningful substantive difference between an ordinary IGCC unit and one that genuinely has been designed with early integration of CO_2 capture in mind. Further, in its FY2008 budget request, the ad-

ministration seeks appropriations allowing it to provide $9 billion in loan guarantees under Title XVII of the Act, including as much as $4 billion in loans for "carbon sequestration optimized coal power plants." The administration request does not define a "carbon sequestration optimized" coal power plant and it could mean almost anything, including, according to some industry representatives, a plant that simply leaves physical space for an unidentified black box. If that makes a power plant "capture-ready" Mr. Chairman, then my driveway is "Ferrari-ready." We should not be investing today in coal plants at more than a billion dollars apiece with nothing more than a hope that some kind of capture system will turn up. We would not get on a plane to a destination if the pilot told us there was no landing site but options were being researched.

GEOLOGIC DISPOSAL

We have a significant experience base for injecting large amounts of CO_2 into geologic formations. For several decades oil field operators have received high pressure CO_2 for injection into fields to enhance oil recovery, delivered by pipelines spanning as much as several hundred miles. Today in the U.S. a total of more than 35 million tons of CO_2 are injected annually in more than 70 projects. (Unfortunately, due to the lack of any controls on CO_2 emissions, about 80 per cent of that CO_2 is sources from natural CO_2 formations rather than captured from industrial sources. Historians will marvel that we persisted so long in pulling CO_2 out of holes in the ground in order to move it hundreds of miles and stick in back in holes at the same time we were recognizing the harm being caused by emissions of the same molecule from nearby large industrial sources.) In addition to this enhanced oil recovery experience, there are several other large injection projects in operation or announced. The longest running of these, the Sleipner project, began in 1996.

But the largest of these projects injects on the order of one million tons per year of CO_2, while a single large coal power plant can produce about five million tons per year. And of course, our experience with man-made injection projects does not extend for the thousand year or more period that we would need to keep CO_2 in place underground for it to be effective in helping to avoid dangerous global warming. Accordingly, the public and interested members of the environmental, industry and policy communities rightly ask whether we can carry out a large scale injection program safely and assure that the injected CO_2 will stay where we put it.

Julio Friedmann's testimony addresses these questions at length and with much greater authority that I can supply so I will simply summarize the findings of the IPCC on these issues. In its 2005 report the IPCC concluded the following with respect to the question of whether we can safely carry out carbon injection operations on the required scale:

> With appropriate site selection based on available subsurface information, a monitoring programme to detect problems, a regulatory system and the appropriate use of remediation methods to stop or control CO_2 releases if they arise, the local health, safety and environment risks of geological storage would be comparable to the risks of current activities such as natural gas storage, FOR and deep underground disposal of acid gas.

The knowledge exists to fulfill all of the conditions the IPCC identifies as needed to assure safety. While EPA has authority regulate large scale CO_2 injection projects its current underground injection control regulations are not designed to require the appropriate showings for permitting a facility intended for long-term retention of large amounts of CO_2. With adequate resources applied, EPA should be able to make the necessary revisions to its rules in two to three years. We urge this Committee to work with other committees of Congress to require EPA to undertake this effort this year.

Do we have a basis today for concluding that injected CO_2 will stay in place for the long periods required to prevent its contributing to global warming? The IPCC report concluded that we do, stating:

> Observations from engineered and natural analogues as well as models suggest that the fraction retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years.

Despite this conclusion by recognized experts there is still reason to ask what are the implications of imperfect execution of large scale injection projects, especially in the early years before we have amassed more experience? Is this reason enough to delay application of CO_2 capture systems to new power plants until we gain such experience from an initial round of multi-million ton "demonstration" projects? To

sketch an answer to this question, my colleague Stefan Bachu, a geologist with the Alberta Energy and Utilities Board, and I wrote a paper for the Eighth International Conference on Greenhouse Gas Control Technologies in June 2006. The obvious and fundamental point we made is that without CO_2 capture, new coal plants built during any "delay and research" period will put 100 per cent of their CO_2 into the air and may do so for their operating life if they were "grandfathered" from retrofit requirements. Those releases need to be compared to hypothetical leaks from early injection sites.

Our conclusions were that even with extreme, unrealistically high hypothetical leakage rates from early injection sites (10% per year), a long period to leak detection (5 years) and a prolonged period to correct the leak (1 year), a policy that delayed installation of CO_2 capture at new coal plants to await further research would result in cumulative CO_2 releases twenty times greater than from the hypothetical faulty injection sites, if power plants built during the research period were "grandfathered" from retrofit requirements. If this wave of new coal plants were all required to retrofit CO_2 capture by no later than 2030, the cumulative emissions would still be four times greater than under the no delay scenario. I believe that any objective assessment will conclude that allowing new coal plants to be built without CO_2 capture equipment on the ground that we need more large scale injection experience will always result in significantly greater CO_2 releases than starting CO_2 capture without delay for new coal plants now being designed.

The IPCC also made estimates about global storage capacity for CO_2 in geologic formations. It concluded as follows:

> Available evidence suggests that, worldwide, it is likely that there is a technical potential of at least about 2,000 $GtCO_2$ (545 GtC) of storage capacity in geological formations. There could be a much larger potential for geological storage in saline formations, but the upper limit estimates are uncertain due to lack of information and an agreed methodology.

Current CO_2 emissions from the world's power plants are about 10 Gt (billion metric tons) per year, so the IPCC estimate indicates 200 years of capacity if power plant emissions did not increase and 100 years capacity if annual emissions doubled.

POLICY ACTIONS TO SPEED CCD

As I stated earlier, research and development funding is useful but it cannot substitute for the incentive that a genuine commercial market for CO_2 capture and disposal systems will provide to the private sector. The amounts of capital that the private sector can spend to optimize CCD methods will almost certainly always dwarf what Congress will provide with taxpayer dollars. To mobilize those private sector dollars, Congress needs a stimulus more compelling than the offer of modest handouts for research. Congress has a model that works: intelligently designed policies to limit emissions cause firms to spend money finding better and less expensive ways to prevent or capture emissions.

Where a technology is already competitive with other emission control techniques, for example, sulfur dioxide scrubbers, a cap and trade program like that enacted by Congress in 1990, can result in more rapid deployment, improvements in performance, and reductions in costs. Today's scrubbers are much more effective and much less costly than those built in the 1980s. However, a CO_2 cap and trade program by itself may not result in deployment of CCD systems as rapidly as we need. Many new coal plant design decisions are being made literally today. Depending on the pace of required reductions under a global warming bill, a firm may decide to build a conventional coal plant and purchase credits from the cap and trade market rather than applying CCD systems to the plant. While this may appear to be economically rational in the short term, it is likely to lead to higher costs of CO_2 control in the mid and longer term if substantial amounts of new conventional coal construction leads to ballooning demand for CO_2 credits. Recall that in the late 1990's and the first few years of this century, individual firms thought it made economic sense to build large numbers of new gas-fired power plants. The problem is too many of them had the same idea and the resulting increase in demand for natural gas increased both the price and volatility of natural gas to the point where many of these investments are idle today.

Moreover, delaying the start of CCD until a cap and trade system price is high enough to produce these investments delays the broad demonstration of the technology that the U.S. and other countries will need if we continue substantial use of coal as seem likely. The more affordable CCD becomes, the more widespread its use will be throughout the world, including in rapidly growing economies like China

and India. But the learning and cost reductions for CCD that are desirable will come only from the experience gained by building and operating the initial commercial plants. The longer we wait to ramp up this experience, the longer we will wait to see CCD deployed here and in countries like China.

Accordingly, we believe the best policy package is a hybrid program that combines the breadth and flexibility of a cap and trade program with well-designed performance measures focused on key technologies like CCD. One such performance measure is a CO_2 emissions standard that applies to new power investments. California enacted such a measure in SB1368 last year. It requires new investments for sale of power in California to meet a performance standard that is achievable by coal with a moderate amount of CO_2 capture.

Another approach is a low-carbon generation obligation for coal-based power. Similar in concept to a renewable performance standard, the low-carbon generation obligation requires an initially small fraction of sales from coal-based power to meet a CO_2 performance standard that is achievable with CCD. The required fraction of sales would increase gradually over time and the obligation would be tradable. Thus, a coal-based generating firm could meet the requirement by building a plant with CCD, by purchasing power generated by another source that meets the standard, or by purchasing credits from those who build such plants. This approach has the advantage of speeding the deployment of CCD while avoiding the "first mover penalty." Instead of causing the first builder of a commercial coal plant with CCD to bear all of the incremental costs, the tradable low-carbon generation obligation would spread those costs over the entire coal-based generation system. The builder of the first unit would achieve far more hours of low-carbon generation than required and would sell the credits to other firms that needed credits to comply. These credit sales would finance the incremental costs of these early units. This approach provides the coal-based power industry with the experience with a technology that it knows is needed to reconcile coal use and climate protection and does it without sticker shock. A bill introduced in the other body, S. 309, contains such a provision. It begins with a requirement that one-half of one per cent of coal-based power sales must meet the low-carbon performance standard starting in 2015 and the required percentage increases over time according to a statutory minimum schedule that can be increased in specified amounts by additional regulatory action.

A word about costs is in order. With today's off the shelf systems, estimates are that the production cost of electricity at a coal plant with CCD could be as much as 40% higher than at a conventional plant that emits its CO_2. But the impact on average electricity prices of introducing CCD now will be very much smaller due to several factors. First, power production costs represent about 60% of the price you and I pay for electricity; the rest comes from transmission and distribution costs. Second, coal-based power represents just over half of U.S. power consumption. Third, and most important, even if we start now, CCD would be applied to only a small fraction of U.S. coal capacity for some time. Thus, with the trading approach I have outlined, the incremental costs on the units equipped with CCD would be spread over the entire coal-based power sector or possibly across all fossil capacity depending on the choices made by Congress. Based on CCD costs available in 2005 we estimate that a low-carbon generation obligation large enough to cover all forecasted new U.S. coal capacity through 2020 could be implemented for about a two per cent increase in average U.S. retail electricity rates.

Specific comments on S. 731 and S. 962

S. 731

In considering a portfolio of sites for permanently disposing of CO_2, it will be useful for operators to have a general overview of candidate formations before proceeding to spend funds to test and characterize a site further. A comprehensive assessment of geological capacity to store carbon dioxide in the U.S. such as that called for in S. 731 will be needed to enable large-scale use of CCD. Such a survey can provide considerable benefits for fairly modest costs.

To date, the Carbon Sequestration Regional Partnerships, funded by DOE, have conducted some mapping of disposal capacity and other parameters. In particular, the sources of CO_2 around the country have been characterized and mapped very well. However, limitations exist on the existing mapping of disposal sites, and industry does not have a usable, comprehensive product with which to consider and further investigate suitable sites for CO_2 disposal.

The national carbon atlas, NATCARB, is a significant advance but it has not been compiled according to a uniform, peer-reviewed methodology, with the result that that some data classes over-represented and others under-represented. A more rig-

orous methodology is essential to the quality of the mapping. The bill requires USGS to devise precisely such a methodology, subjecting it to review and public consultation.

In the Regional Partnerships' mapping work, geographical and geological coverage has not been uniform or comprehensive. Several regions were not assessed. It is crucial that the capacity assessment covers all formations in all 50 states. This is a reasonable requirement, which will result in a complete picture of our geological disposal options.

In regions that were examined, uncertainties in geology still exist in some cases, while well data and cross-sections are often absent. The USGS is already in possession of a sizeable portion of the data that would be published as part of the survey proposed by the bill, and we believe is a body capable of producing a product that will be comprehensive, scientifically rigorous and usable by industry. In doing so, the bill would require it to address four key parameters: the available volume for disposing of CO_2, the rate at which it can be injected and how long such injection rates can be sustained, the associated risks with reservoirs, and an estimate of the costs that would be involved in carrying out the injection.

S. 731 calls for a modest appropriation of $20 million to be distributed to the USGS and DOE. We believe this legislation is not a threat to DOE's CCD program efforts to date but a complement. We view the work called for by this bill as a logical continuation of work that has been carried out already. The bill calls for coordination between USGS and DOE to ensure that existing work is fed into the process in a meaningful way.

A comprehensive mapping effort for the U.S. is very important if we are to choose good disposal sites effectively, avoid pitfalls and reduce survey CO_2 transportation costs. Australia has already demonstrated the merits of this approach, as well as its feasibility, through the GEODISC project. We should be aiming to replicate and improve on their success.

S. 962

Current criteria and objectives under the Energy Policy Act of 2005 for the Carbon Capture Research and Development Program are not sufficiently focused, nor do they ensure that funds are spent in a manner optimal for addressing pending research questions and accelerating the use of the technology. Reforming these requirements is necessary, and we welcome Senator Bingaman's initiative to do so.

S. 962 would ensure that authorized funds are not spent only on research and development, but lead to *actual demonstration* of the technologies. Additionally, the general objective of the Program would be broadened from "carbon dioxide capture technologies on combustion-based systems" to "capture and storage technologies related to energy systems". These two amendments send a much clearer signal as to what the program should aim to achieve. The demonstration requirement would provide a much stronger safeguard that any research conducted leads to real applications that have the potential to be commercialized and/or used widely. The inclusion of storage alongside capture is also of prime importance: one of the key needs for moving forward with carbon capture and storage in the energy sector is the integration of the capture and storage elements of the technology. Conducting large-scale injections of CO_2 for demonstration and more comprehensive documentation purposes is recognized as a priority—we fully concur that this there is a pressing need to conduct these injections promptly, and to ensure that they are conducted in a way that will shed light in areas where uncertainties currently remain.

We also very pleased to note the bill's provisions that prescribe well-thought out and specific programmatic activities. The description of these activities sets a much clearer direction as to how research should be applied. The intended role of the Regional Partnerships is also further focused, with emphasis being placed on injection projects and monitoring operations. We welcome the intent to consider a variety of geological formations. The objectives spelled out for the tests carried out by the Partnerships also help to ensure that they are conducted in a concerted way, and are designed and carried out in order to answer concrete questions. We also hope that these objectives will ensure the dissemination of all relevant information and lessons learned in a comprehensive and timely manner.

S. 962 would ensure that at least seven large-scale injection projects are carried out, and that they are carried out with defined objectives. We believe an objective to collect additional information needed to assure long-term retention of injected CO_2 should be added to the bill. We urge that the bill define "large-scale" to mean injection of more than one million metric tons of CO_2 annually. In addition, we believe it is important to provide for independent review and oversight of this injection

program to ensure its benefits are maximized. The National Academy of Sciences is one institution that should be considered to carry out this function.

NRDC believes that the large-scale injections should be understood as an integral component of a policy to move forward with near-term deployment of CCD. New coal-fired power plants continue to be proposed in the U.S. and NRDC believes any such plants should employ CCD. The large-scale injection projects called for in S. 962 can serve as repositories for the CO_2 produced by such plants. Thus, these projects should not be thought of as short-term operations that will be operated for a few years and then shut down. This should be clarified in the bill by requiring a timeline for these projects to receive permits from EPA for operation as permanent repositories. We urge that the bill also specify that anthropogenic CO_2 be used in the projects funded by the legislation, as opposed to the use of naturally occurring or recycled CO_2.

Moreover, we believe that the need for these projects is urgent enough to justify their prompt commencement, and therefore propose that they begin at the earliest possible opportunity, and not later than FY2009. In this regard, the bill should direct the Secretary to give priority to projects that can be deployed rapidly. A likely sequence would be to commence large-scale injection with existing high-concentration industrial sources, followed by injection of larger amounts of CO_2 from coal-based power plants. The bill should direct the Secretary to structure the program to enable this approach.

Although we note the threefold or more increase in the authorization compared to EPAct 2005, we have serious concerns that the suggested funding levels would not suffice to carry out the large scale injections described in the bill, or meet the overall objectives. The recently published MIT coal study presents a breakdown of the cost components of such an injection project. These include a site survey and information gathering, the drilling of wells, purchase costs for CO_2, compression, monitoring and verification, modeling and site closure costs. The MIT study produces annual cost estimates of $13-28 million per project, for projects that inject about one million tons of CO_2 annually. In order to conduct seven projects of over one million tons annually, as well as carry out other supporting work increased funding levels on the order of $200 million per year are likely to be needed. We recommend the duration of program funding be increased to four and preferably five years.

We also welcome the minimum industry participation requirements for the activities funded by S. 962. It is important to ensure that the private sector will have an incentive to invest in these technologies and that public funds lead to wide-scale diffusion and not one-off demonstrations.

Finally, I want to repeat the importance of complementing the activities called for in these bills with prompt adoption of permitting and operational requirements for CO_2 disposal by EPA. We believe Congress should pass legislation this year directing EPA to carry out such rulemaking without delay. We encourage this Committee to work with the Environment and Public Works and the Appropriations Committees to promote this goal.

CONCLUSIONS

To sum up, since we will almost certainly continue using large amounts of coal in the U.S. and globally in the coming decades, it is imperative that we act now to deploy CCD systems. Commercially demonstrated CO_2 capture systems exist today and competing systems are being researched. Improvements in current systems and emergence of new approaches will be accelerated by requirements to limit CO_2 emissions. Geologic disposal of large amounts of CO_2 is viable and we know enough today to conclude that it can be done safely and effectively. EPA must act without delay to revise its regulations to provide the necessary framework for efficient permitting, monitoring and operational practices for large scale permanent CO_2 repositories. The survey and capture and large-scale injection projects that are called for in S. 731 and S. 962 are important steps to take and NRDC supports this work.

Finally CCD is an important strategy to reduce CO_2 emissions from fossil fuel use but it is not the basis for a climate protection program by itself. Increased reliance on low-carbon energy resources is the key to protecting the climate. The lowest carbon resource of all is smarter use of energy; energy efficiency investments will be the backbone of any sensible climate protection strategy. Renewable energy will need to assume a much greater role than it does today. With today's use of solar, wind and biomass energy, we tap only a tiny fraction of the energy the sun provides every day. There is enormous potential to expand our reliance on these resources.

We have no time to lose to begin cutting global warming emissions. Fortunately, we have technologies ready for use today that can get us started.

Mr. Chairman, that completes my testimony, I will be happy to take any questions you or other committee members may have.

The CHAIRMAN. Thank you very much.

Mr. Coddington.

STATEMENT OF KIPP CODDINGTON, PARTNER, ALSTON & BIRD LLP

Mr. CODDINGTON. Thank you, Mr. Chairman and members of the committee. I thank you for the opportunity to appear before you today to discuss the liability issues that currently stand as an impediment to the commercial deployment of carbon capture and storage technology in the United States.

I am Kipp Coddington, a partner in the law firm of Alston & Bird. The firm represents a number of companies who are engaged in carbon-based projects worldwide, but I add that my testimony today is mine alone and does not represent the views of any individual company.

First off, let me commend the sponsors of the legislation that are the topic of today's hearing. Both bills place a necessary priority on advancing our knowledge and understanding of carbon capture and storage technology, or CCS.

Although I deem CO_2 injection and geologic storage to be a proven technology in many contexts, conducting these operations more broadly domestically or in different classes of geologic reservoirs, particularly in the face of uncertain carbon management requirements, will require resolution of a host of challenging issues, not the least of which is liabilities associated with the long-term geologic storage of carbon dioxide. This afternoon, I'd like to discuss just three of those categories of liabilities with you.

The first are liabilities associated with an uncertain regulatory regime. While fluid injection and retention are well understood and competently regulated in many contexts—for example, CO_2-EOR and natural-gas storage—there are no Federal or State rules dedicated to CCS. Both Federal EPA and the Interstate Oil and Gas Compact Commission are working on those—their own regulations, but those regulations are expected to differ in key respects.

The second category are liabilities associated with environment natural-resource damage issues. Existing environmental laws were not created with carbon storage in mind. To the extent that they could be applied to that practice, they tend to focus on the nature of the constituent of interest; here, carbon dioxide. It's my view that carbon injection and storage is unlikely to occur if carbon dioxide is deemed a waste for purposes of these laws, and I also believe that issue is currently unresolved, unfortunately. Those laws also overlook other subsurface features and attributes, such as mineral rights and resources, which also require attention and that historically have been the domain of State, not Federal, concern. Geologic storage has as much to do with energy and mineral rights as it has to do with the environment.

The third, and final, category includes all climate-related liabilities. Will geologic storage be recognized under a possible new Federal climate law, for example? It is critical that geologic storage be

so recognized, in my view, if the technology is to be widely deployed.

Now, hope is not lost, because there are some answers to these problems. The most effective answer is for the Government to assume liability for the injected carbon dioxide at some fixed state, perhaps at the conclusion of injection activities, well-plugging, or, alternatively, at the end of a post-closure period. This concept is not new, as some of the prior testimony has heard. The State of Texas, for example, in the context of FutureGen, has enacted a bill that makes the State liable for injected plumes of CO_2. The Norwegian government, for example, is considering a similar model, in which they're setting up a state-owned corporation, effectively, to manage geologically injected carbon dioxide.

Now, this approach does not mean that Federal or State governments in the United States would be left with uncertain risk under a moral-hazard theory. Standards and protocols could be developed that preclude the injection and storage of carbon dioxide in inappropriate geologic conditions, for example. Other solutions are worth consideration, too, and I've tried to highlight a few of those in my more extensive written testimony.

In conclusion, if geologic storage is to be widely deployed in the United States, liabilities will need to be addressed, with the Government playing a key role. Failure to do so is likely to impede the construction of billions of dollars of productive CCS-related infrastructure in the years ahead, and to the detriment of the carbon-based fuels that may be expecting that infrastructure to be there to support them.

This concludes my testimony, Mr. Chairman and members of the committee, and I'd be pleased to answer any questions that you may have.

Thank you.

[The prepared statement of Mr. Coddington follows:]

PREPARED STATEMENT OF KIPP CODDINGTON, ESQ., PARTNER, ALSTON & BIRD LLP

Mr. Chairman and Members of the Committee, thank you for the opportunity to appear before you today to discuss some possible solutions to the liability issues that currently stand as an impediment to the commercial deployment of carbon capture & storage ("CCS") technology in the United States. I am Kipp Coddington, a partner in the law firm Alston & Bird LLP. The firm represents a number of companies who are engaged in the CCS and CO_2-EOR industries, and carbon-based projects worldwide, but add that my testimony today is mine alone and does not represent the views of any company.

In the interests of time, my comments today are focused on liability issues associated with the long-term storage of industrial emissions of carbon dioxide in geologic reservoirs, as opposed to those arising from capture and pipeline transportation.

INTRODUCTION

First off, let me commend the sponsors of the legislation that are the topic of today's hearing: S. 731, which focuses on a national assessment of geologic storage capacity, and S. 962, which focuses on R&D and the large-scale deployment of geologic storage tests in advance of the "commercial deployment of technologies for [the] geologic containment of carbon dioxide" (§ 2). Both bills place a necessary priority on advancing our knowledge and understanding of CCS, and envision a day when these technologies will be deployed throughout the Nation.

I share the vision of a prosperous CCS industry in the United States and the associated benefits it would bring in terms of jobs, tax revenue, and greater energy independence (via CO_2-EOR, for example). Geologic injection and storage operations have occurred safely in many locations of the United States—the Permian Basin, for example—and other areas of the world for many decades.

Depending upon the outcome of the ongoing carbon management debates, I perceive a day in the future when facilities such as CTL, IGCC and the like are safely injecting CO_2 under a regulatory regime that is rigorous, certain and with broad public acceptance of the practice. CCS may be the only path forward in a carbon-constrained world for fuels such as coal and industrial facilities such as power generation. For the same reason, I believe that it is critical that CCS be expressly recognized in any federal, State or regional cap-and-trade program.

Although I deem CO_2 injection and geologic storage to be a proven technology in many contexts, conducting geologic injection and long-term storage operations more broadly domestically or in different classes of geologic reservoirs, particularly in the face of uncertain carbon management requirements, will require resolution of a host of challenging legal, regulatory, policy, financial and technical issues.

One of the most challenging issues is liabilities associated with the long-term geologic storage of carbon dioxide.

LIABILITIES ASSOCIATED WITH THE LONG-TERM GEOLOGIC STORAGE OF CO_2

Numerous liabilities are associated with the long-term geologic storage of CO_2. The existence of these liabilities should not be interpreted to suggest that the geologic storage of CO_2 is unsafe. I believe that geologic storage in the proper subsurface reservoir is inherently safe and holds great promise for wider application, based upon the oil & gas industry's long experience with CO_2-EOR and the research which has been conducted on CCS to date. The existence of liabilities nonetheless can and will impede commercial CCS projects because, today at least, CCS liabilities could be characterized as un-quantifiable uncertainties. The deployment of CCS technology will require billions of dollars in capital expenditures by industry, and those types of investments are not made in the face of un-quantifiable uncertainties. Capital expenditures will only be made and facilities will only get built if project liabilities are identified, quantified and minimized.

Liabilities associated with the long-term geologic storage of CO_2 may be divided into several categories, as follows.

The first category is liabilities associated with an uncertain regulatory regime. While fluid injection and retention are well understood and competently regulated in many contexts—e.g., oil & gas water flooding (secondary recovery), CO_2-EOR and natural gas storage—there is no dedicated CCS regulatory regime. The federal Environmental Protection Agency has issued R&D injection guidance under the Safe Drinking Water Act, with the primary endpoint of concern being protection of drinking water aquifers. The Interstate Oil & Gas Compact Commission, meanwhile, is working on its own State-based regulations for CCS. Commercial companies need regulatory certainty, and such regulatory certainty is lacking today for the CCS industry in the United States.

The second category is liabilities associated with environmental/natural resource damage claims. Numerous federal and State environmental laws could potentially be applied to companies engaged in the injection and long-term geologic storage of carbon dioxide for purposes other than CO_2-EOR. Those laws typically operate by focusing on particular environmental features that are to be protected (e.g., drinking water aquifers) or by applying regulatory requirements based upon the label which applies to the specific constituent of concern—i.e., under the Resource Conservation & Recovery Act, vastly differently regulatory regimes apply depending upon whether a waste is hazardous or non-hazardous.

These existing environmental laws could create liabilities for companies wishing to engage in CCS. For starters, none of them was enacted with CCS in mind, a situation that itself creates uncertainty because it deprives companies of an unambiguous legal framework to conduct their operations. By approaching CCS from a traditional environmental perspective, the laws also overlook other subsurface features and attributes, such as mineral rights and resources, which also require attention and that historically have been the domain of State, not federal, concern.

Additionally, the laws' focus on the nature of the specific constituent means that the legal label which applies to carbon dioxide when it is injected into the subsurface and thereafter geologically stored is important. I believe that the CCS industry could be crippled if carbon dioxide is deemed a waste when in the subsurface. The CO_2 which is being injected into the subsurface today is not deemed a waste, an approach which has spurred the environmentally safe injection of significant volumes of carbon dioxide through stringent, State-based regulations and oversight.[1]

[1] In Texas alone, for example, there are 10,000 permitted carbon dioxide injection wells, 8,000 of which inject carbon dioxide exclusively. Since the initiation of CO_2 injection activities in the Permian Basin several decades ago, approximately 9.6 tcf (or 550 million tons) of carbon dioxide

Unfortunately, I am worried about the regulatory label which applies to carbon dioxide. For example, on April 2, 2007, in its *Massachusetts* v. *EPA* decision, the United States Supreme Court declared carbon dioxide an "air pollutant" for purposes of the federal Clean Air Act. Some media reporting on that case unfortunately referred to greenhouse gas emissions as hazardous or dangerous gases.[2] Even if *Massachusetts* v. *EPA* could be distinguished in this context because it deals with air emissions, I worry about what the case portends for future public acceptance of geologic storage in the United States.[3]

The third category is liabilities associated with mineral rights and resources. CCS has as much to do with energy and mineral rights as it does with the environment, a consideration which is sometimes overlooked in the rush to pigeonhole CCS regulation into the framework of existing environmental laws. If my injected plume inadvertently interferes with my neighbor's natural gas storage facility, who is responsible and what laws apply? Similarly, who owns the pore space into which the CO_2 is injected? Is it the mineral estate or the surface estate? Who owns the plume? The answers to these questions are critically important for commercial CCS operators.[4]

The mere existence of these questions, meanwhile, raises an interesting issue of federalism—namely, these and related real property issues historically have been an exclusive matter of State real property law, regulatory expertise, authority and control. The State geologic surveys, mineral resource boards, and oil & gas commissions possess the reservoir data and employ the geologists and reservoir engineers who understand the subsurface.

Moreover, under State real property law, mineral ownership rights historically were severed from the surface estate and subjected to multiple ownership rights by subsequent assignment to numerous parties, none of whom typically is the federal government (with the usual exception being federal lands). Would a new federal CCS regulatory regime federalize real property law?[5]

Meshing these State-based regulatory responsibilities and considerations with a possible federal CCS regulatory regime that is focused on drinking water aquifers would take great care and attention to develop.

The fourth and final category includes all climate-related liabilities. Will CCS be recognized under existing State/regional and a possible future federal climate regime, such as cap-and-trade, and even if it is so recognized, how will it be regulated? Will geologic storage be covered as a means of compliance? Will the reservoir operator receive allowances? Will the act of geologic storage be eligible to generate offset credits under the cap-and-trade scheme, and if so which party in the CO_2 value chain would be eligible to receive those credits?[6] Will the new standing requirement

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have been stored in geologic reservoirs there. Source: Steve Melzer, Melzer Consulting, (Midland, Texas).

[2] Arguably in conflict with Massachusetts v. EPA, the U.S. Department of Transportation ("DOT") regulates carbon dioxide as a non-hazardous liquid for purposes of pipeline transportation (see 49 C.F.R. part 195 (2006). Does this mean that the legal status of captured carbon dioxide emissions from an industrial source switches from air pollutant to non-hazardous liquid at the moment they are compressed and put into a pipeline?

[3] The role of public acceptance of CCS technology, including education, is critical, and next to liability resolution, may be among the greatest challenges facing the U.S. CCS industry. Internationally, public acceptance to CCS is growing. The EU, for example, has adopted pro-CCS policies recently and in countries such as the UK, Norway, and Australia, the practice is generally well supported and understood (which is not to suggest that those countries do not face challenges of their own). The world's first CCS law was actually implemented in Australia. International codes are also moving in a pro-CCS direction: a 2006 amendment (effective February 10, 2007) to the 1996 Protocol to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter now allows the sub-seabed injection of carbon dioxide for CCS purposes, for example.

[4] To the extent that answers to these questions exist, they likely are rooted in State common law principles governing real property/mineral rights and the State oil & gas codes. These laws, which vary by State, have reasonably resolved a variety of comparable injection-related issues over the decades. Secondary recovery/water flooding technology, for example, faced similar liability questions when it first appeared on the scene many years ago but now enjoys widespread and safe use, with liabilities being addressed in the ordinary course of business. I thus suspect that the answers to at least some of the CCS liabilities will be found or developed through the legal interpretation of existing State energy/property/mineral resource laws or amendments to the same.

[5] This issue is not hypothetical. The low-carbon generation provisions of S. 309, for example, refer to federally approved geologic reservoirs.

[6] The Clean Development Mechanism's ("CDM") Executive Board under the Kyoto Protocol is currently considering several CCS-related proposals. If approved, such projects would be able to generate certified emission reduction credits under the CDM Mechanism. To the extent that a regional (e.g., RGGI) or federal cap-and-trade program allowed the use of international carbon

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set forth in *Massachusetts* v. *EPA* subject the CCS industry to billion dollar claims from the plaintiffs' bar on the theory that a possible 1% leakage rate of CO_2 from a reservoir over a thousand-year period might contribute to degradation of Massachusetts' shoreline? Will a regulator, after injection operations have concluded, impose a constituent requirement on the stored fluid?[7]

If CCS is to go forward commercially, I believe that it is critical that these and related questions be explicitly and favorably addressed in whatever climate laws may be developed. Failure to do so would stall the deployment of the technology commercially.

WHY LIABILITIES/UNCERTAINTIES MAY IMPEDE CCS TRANSACTIONS

Certain CCS projects—e.g., those dedicated exclusively to the long-term storage of carbon dioxide in deep saline aquifers—will be costly (to the tune of billions of dollars) and complex to build. Doing a large-scale commercial CCS deal will require complex negotiations among numerous sophisticated parties—the industrial source, the capture company, the pipeline company, the drilling contractor, the injection company, the reservoir operator and, for each, their bankers, insurers, engineering firms and consultants. Financing would have to be arranged, and even if a company were to do such a project off balance sheet, it likely would face internal financial reviews as stringent as what Wall Street might require. All of those companies would have to allocate the carbon risks among them. While I believe that such deals are doable, doing them in the face of the uncertain liabilities highlighted above would be a tall order.[8] If the liabilities were clarified, I believe that many of these deals would move forward.

Moreover, CCS projects will last a very long time. A typical CO_2-EOR project may last ten to thirty years; a long-term geologic storage facility (either post CO_2-EOR or a reservoir dedicated for storage purpose) may be expected to last for substantially longer—and perhaps an eternity. Even if the potential liabilities associated with CCS were identified and quantified—and they are not, as highlighted above—I am not aware of any commercially responsible company that would agree to assume such liabilities for an eternity based upon current law and policy.

SOME POSSIBLE SOLUTIONS

I believe that the best way to minimize the liability challenges facing CCS is for the government to assume liability for the geologically injected carbon dioxide at some fixed date, perhaps at the conclusion of injection activities, well plugging, or, alternatively, at the end of a post-closure period.

This concept is not new. For example, the State of Texas, in the context of FutureGen, enacted legislation that made the State liable for injected plumes of CO_2. The Norwegian government is considering a similar model—one which perceives a dominant role by a government-owned corporation in the long-term management of the geologically stored carbon dioxide.

This approach does not mean that the government would be left with uncertain risks under a moral hazard theory. Standards and protocols could be developed that preclude the injection and storage of carbon dioxide in inappropriate geologic conditions or sensitive areas. The standards and protocols might also specify other conditions that must be met, perhaps during a defined closure period, before the government would assume responsibility.

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credits in some scenarios, those CCS-related credits (if ultimately approved internationally, and that's an open question) presumably could also be used in the United States.

[7] For purposes of pipeline transportation, DOT defines carbon dioxide as a "fluid consisting of more than 90 percent carbon dioxide molecules compressed to a supercritical state." See 49 C.F.R. § 195.2 (2006). This definition has served the public, industry and government well for many years.

[8] Projects based solely on CO_2-EOR could proceed even in the face of the current uncertainties. CO_2-EOR is a mature, safe and proven technology that has been regulated by the States for decades. In the worthwhile effort to further a CCS industry in the United States, no action should be taken to impair CO_2-EOR, and I am not aware of any pending regulatory approaches that would do so. The issue for CO_2-EOR may instead be whether the practice would be excluded from the coming CCS regulatory regime. That would be an unfortunate result, as I believe that CO_2-EOR is in fact geologic storage. The Permian Basin could fairly be viewed as one of the world's largest CO_2 storage sites. *See note 1, supra.* CO_2-EOR also is a technology that, in part through market forces, holds the promise of expediting the build-out of some CCS infrastructure. This is not to suggest that CO_2-EOR is a panacea that will enable a CCS industry on its own. CO_2 floods are costly, technically challenging, and face tough project economics, even with oil at $60/barrel.

Based upon the current legal, policy, and regulatory environment, any solution short of the government assuming all liabilities at some future date would run the risk of hindering the commercial deployment of CCS technology.

Other approaches could be considered, however. For example, the government could back-stop the private insurance markets in an effort to induce insurers to accept the liabilities.[9] This solution may be insufficient, however, because of concerns within the insurance industry about taking on "eternal" risks, too. Even if the insurers would agree to insure the risks, the premiums and other attributes of such coverage could make CCS projects non-viable for commercial reasons.[10]

Another manner in which liabilities could be managed, although not eliminated in a way that might enable the full deployment of commercial CCS technology, is to do geologic storage—at least initially—where it makes the most sense from a geologic perspective. Location matters because geology varies. Oil & gas may be found where it is because of the existence of natural traps in those locations, for example. A quick jump start to the industry could be provided by mitigating liabilities in those regions first, while conducting R&D on storage in other geologic structures in other areas of the country.

Finally, I believe that the manner in which carbon dioxide injection is regulated—a theme echoed throughout this testimony—will go a long ways towards determining the manner in which liabilities are addressed, managed and resolved. If CO_2 injection and long-term storage is regulated from the starting position that carbon dioxide is a contaminant that poses substantial environmental risks, I would expect to see few if any commercial CCS facilities built in the foreseeable future.

Conversely, if the subject matter is regulated from the starting position that (i) CO_2 is not a contaminant; (ii) CO_2 injection and storage operations have occurred safely for many years both domestically and abroad in various contexts; (iii) the environmental risks are identifiable and subject to responsible regulation; and (iv) the States have substantial experience in dealing with subsurface matters and that experience should not be overlooked or trumped, I would expect to see a commercial CCS industry start and maybe even flourish. And I would expect that industry to bring the Nation a variety of energy, environmental, and economic benefits to all stakeholders, including the public.

Congress has been in this position before. In 1980, Congress amended with Safe Drinking Water Act to exempt the injection of natural gas for purposes of storage.[11] Congress did so on the notion that there was scant evidence that the practice threatened drinking water aquifers and that natural gas storage operators had an incentive to minimize, if not eliminate, reservoir leakage. I believe that similar arguments could be made for CCS today. Since that time, the natural gas storage industry has grown and the public interest served through competent regulation at both levels of government (e.g., the federal Natural Gas Act of 1938 and State-by-State laws/regulations that include well performance standards and related matters).

With appropriate regulation of liabilities in mind, it thus might be worthwhile for Congress to consider whether regulation of non-CO_2-EOR CCS under the Safe Drinking Water Act's Underground Injection Control ("UIC") program is necessarily the only logical starting point for regulation. It may be. I just do not believe that the analysis has been done to support such a determination.

CONCLUSION

In conclusion, I commend that Committee for its efforts to examine CCS, including geologic storage. S. 731 and S. 962 are critically important pieces of legislation because they will help to pave the way for the commercial CCS industry in the United States.

Looking beyond those bills to the day when commercial players are engaged in the new CCS industry, policymakers will need to address liability issues associated with long-term geologic storage of carbon dioxide. Failure to do so is likely to stall, if not impede, the construction of billions of dollars of productive CCS-related infrastructure in the United States in the years ahead—and to the detriment of carbon-based fuels that may be expecting that infrastructure to be there to support them.

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[9] See K. Coddington, "A Model CCS Code: Establishing the Regulatory Framework & Incentives to Enable Technology Deployment", 5th Annual Conference on Carbon Capture & Sequestration, May 2006.

[10] All insurance-based solutions are complicated but worthy of further analysis. The Price-Anderson Act, for example, has been cited by many commentators as a possible model for the long-term management of CO_2 storage liability.

[11] 42 U.S.C. § 300h(d)(1)(B)(i) (2006).

I believe that the public interest would best be served if the CCS infrastructure gets built.

This concludes my testimony, Mr. Chairman and Members of the Committee. I would be pleased to answer any questions that you may have.

The CHAIRMAN. Well, Thank you very much.

Thanks to all of you for your excellent testimony. Let me ask a few questions here.

Let me ask Mr. Hawkins. In the summary of your testimony, you have an interesting comment, where you say, here, "Policies to limit CO_2 emissions and set performance standards are essential to drive use of CCD at the required scale and pace. Such policies should be enacted in this Congress. Well-designed measures can phase in CCD on new coal plants with only very modest impacts on retail electricity prices." Could you elaborate a little bit on how you would—you're saying "well-designed measures," what would such a "well-designed measure" look like?

Mr. HAWKINS. Well, we think a combination of a set of performance requirements and a cap-and-trade program will be most effective in both sending a signal throughout the economy that it's important to limit CO_2 emissions, but having some targeted performance standards. And the example that I was referring to in the summary was modeled on a renewable portfolio standard, but it would be basically a low-carbon-generation standard that would say that a certain fraction of electricity sales need to be met through the use of coal-based electricity that meets a CO_2 performance standard. And this would address the question that Mr. Shope, from DOE, talked about, which is the rollout of this technology. It's really, I think, the wrong vision to think about this technology's not being here today, and, you flip a switch, and all of a sudden it's widely deployed in 2045. That's not the way it's going to happen. It's going to happen one powerplant at a time. And what we need to do is not build anymore conventional powerplants that emit their CO_2 to the atmosphere. And Congress should take a combination of incentives and performance standards to make that happen. We know enough now to start, with the next powerplant that's in the design stage, to start capturing its carbon and disposing of it. We have sufficient experience that we know we can dispose of it safely. What we lack are the policy incentives to do it. If we did so, though, we've done a calculation, with Princeton University, which indicated that we could accommodate all—we could pay the incremental costs for all of the forecasted new coal capacity out to 2020, and the impact on electricity rates nationally would be an average of about 2 percent.

The CHAIRMAN. Okay. Then you're suggesting that, rather than a renewable portfolio standard, which has been the subject of a lot of debate around this Congress and previous Congresses for many years, rather than that, we ought to be looking at a low-carbon-generation standard.

Mr. HAWKINS. Let me be clear, Senator, we are not saying that this should be done "rather" than a renewable portfolio standard, we think a renewable portfolio standard stands on its own merits, it's very important. We urge Congress to enact one. But we are saying that there is another resource that is important to promote, as well, because we are not stopping building coal plants. So, we have

another resource that we need to pay attention to, which is keeping the carbon in coal-fired powerplants out of the atmosphere, and that can be addressed by a similar approach to a renewable portfolio standard. That is a tradable obligation that is a fraction of the electricity sales. But this is most definitely not a substitute for a renewable portfolio standard. We very strongly support enactment of a renewable portfolio standard, as well.

The CHAIRMAN. Okay.

Let me ask you, Mr. Coddington—your suggestion that the solution to this problem, or much of the solution to this liability problem that you outlined for us, is for the geologically injected carbon dioxide at some fixed date, perhaps at the conclusion of the injection activities and well-plugging, to be—for the Government to assume the liability for that, as I understand it.

Mr. CODDINGTON. Correct.

The CHAIRMAN. Are you also suggesting that the title to that would transfer, some way or other? I mean, how does that work? I mean, CO_2 has a value, and is sold on the market today for injection in gas wells, and for other purposes. Are you suggesting that the Government should take the liability for releases of it—unanticipated releases, but ownership should stay where it is? Or how would that work?

Mr. CODDINGTON. The issue of ownership is an interesting one, and I don't know that I have a particular view on that. My focus is more on the liability issue. And I do think that if the responsibilities were clarified, such that, at a date certain, the Government would take responsibility for that liability, whether that would necessarily have to include title to the injected carbon dioxide, I don't know that that's the case. And, interestingly enough, that answer may vary, depending upon what State you're in, in terms of who actually owns—has title to the fluid in the subsurface. But in terms of enabling the deployment of the technology sooner rather than later, I think clarifying that simple issue would probably do more than anything else, in terms of trying to spur the commercial deployment of the technology. I think it's a huge impediment.

The CHAIRMAN. Senator Domenici.

Senator DOMENICI. Thank you, Senator.

That's interesting, with reference to this last issue. Mr. Hawkins suggests that it not be just one, but both. I would not have—would not have caught that, had not you volunteered it, and I'm glad you did, for now everybody knows what you're thinking about, which is a better way to have it than to go along our merry way for a few months here and then find out you really meant something different.

Let me just talk about a couple of things with you and let you go on your way. We're about ready to proceed with policies that have been discussed by Senator Bingaman, and each of you have added something. Mr. Hawkins, you have requested the most important legislation be added. I don't know what the members are going to think about that, but two or three of them are very large add-ons to the legislation that was being planned to go royally on its way through this committee and to the floor. And knowing where you come from, they will be hot issues by the time you get

around to bringing them up, Mr. Chairman. I think that's pretty obvious to all of us, at this point.

I'm very worried about why it is taking us so long to get where we are. And I think I understand, now, having heard the testimony of the three of you, how difficult it is to move along very fast.

I wonder if you could go ahead and come back to me while I review a couple of things in my mind.

The CHAIRMAN. Certainly.

Senator Salazar.

Senator SALAZAR. Thank you, Chairman Bingaman.

Let me ask a question relative to timing here. We heard Assistant Secretary Shope talk about commercial-scale deployment of this by 2045. I was trying to think about how many people in this room might be around in 2045, and thought, that's a little too far out, and think that the two bills that we are considering here in this committee today hopefully will help us move along on a much faster track, and which is the reason I'm fully supportive of both pieces of legislation, one that will do the assessment and provide us the right methodology, and the second, Senator Bingaman's bill on moving forward with seven commercial-style demonstration projects that can show us how this will work. And I'd like you to comment on the timing of that. I know there is—you know, Xcel is a utility generator in a number of different States. One of the things that they have proposed is an IGCC plant that actually would do carbon storage. My understanding is—Senator Bingaman and my colleagues here—is that they would hope to be able to have that up and running, and actually being able to demonstrate what they can do, and have already identified a couple of alternative geologic formations and sites that they are looking at. But they're looking at this thing happening, not in 2045, they're looking at it happening perhaps 4, 5, 6 years from now. So, 2011, 2012, we ought to be up and running with a powerplant, essentially, that captures carbon and then injects it back into the underground.

And what I'm troubled by, frankly, is that we're not really—I mean, I know we have not done this kind of thing in the large scale that we propose to do it here, but we're dealing with a technology that's been around for a very long time. I mean, in all the oil fields, we know that it's a technology that has been used time and time again. So, I'd like each of you to take a minute or so and just comment about the timing of this and the urgency of it, and how these bills might help us beat that 2045 vision to make it a much quicker time.

Dr. Guthrie, why don't we start with you and just go across the table.

Dr. GUTHRIE. You're right that we do have a lot of experience with some aspects. In terms of CO_2 injection in enhanced oil recovery, we do have experience with that. We have much less experience injecting CO_2 into, for example, saline formations. And so, there are some aspects of the technology that we still need to do at large scale.

However, having said that, I think that—I agree with Mr. Hawkins' comments earlier, in that it's not something that we're going to turn in 2045, but, rather, a technology that we'll begin to do, perhaps, in the next 5 or 10 years and then phase in. And so, I

think we're ready to do full-scale operation at a specific facility and specific site today, but that's different from saying, Is this full-scale implementation for all of the CO_2 emissions that we have in the United States?

Senator SALAZAR. Mr. Hawkins.

Mr. HAWKINS. Thank you, Senator.

Yes, individual powerplants, a scale, as Dr. Guthrie indicated, has been demonstrated. We can do this. We need a set of decisions made that will make it feasible to happen, but we don't need to wait for it to happen. BP is proposing a project in California, that's a 500-megawatt unit, that will capture its CO_2 and inject it. You mentioned the Xcel proposal. I heard Mr. Shope testify a couple of weeks ago with the 2045 figure, and I thought I must have been mistaken, so I actually talked to some of the professional staff at DOE, said, "How can you possibly explain this 2045 date?" And they said, "Well, the 2045 date is the assumption that over that period of time, technology for CO_2 capture, along with other pollutants, will get so cheap that it'll be the technology that would be deployed by the power sector, even if there was no constraint on CO_2 emission limits whatsoever, because of the cost savings associated with capturing the sulfur and injecting that." So, that's the basis of the 2045. It's basically—if you assume that the world does nothing about climate change, you can expect the power sector to respond in 40 years, and that, I think, says all that needs to be said about that.

Senator SALAZAR. Mr. Coddington.

Mr. CODDINGTON. Yes. I think if you do the right project in the right area under clear liability rules, that this could move quite quickly. And by the "right project in the right area," I mean that if—there are obviously regions of the country that have the geology that would be favorable for this, and, if you have the luxury of being able to site your facility, I think there might even be some hunger in the commercial market for those projects to go forward. I think what they're waiting for is clarity regarding regulatory rules, and they're looking for clarity regarding liability protection. I think there is a sense here that maybe that the standard that's being set up is that there's going to be an injection well in everyone's backyard, including in downtown Boston, at some future date, and we're going to start as if we're going to regulate that as the endpoint and sort of think all those issues through. I don't know whether, in my lifetime, there will ever be an injection well in downtown Boston. It very well may come to that. I don't think that's going to happen pretty soon. But I think, in some parts of the country, with the right technology, this could be done quite quickly. But what's needed is clarity regarding rules. What the rules are, what agency has regulatory responsibility and who's responsible?

Senator SALAZAR. Thank you, Mr. Coddington.

If I could have 30 more seconds, Mr. Chairman?

I think what will happen is, as we move forward with these demonstration projects, and as the MIT witness from several weeks ago said in their report, there are probably 20 of these projects around the world, from Canada to Australia to China and what we have going on here in Colorado—I mean, in this country, including Colo-

rado—and what will happen is, we'll see how this technology evolves, and then we may have a new time horizon that's more real, based on actual demonstration projects on the ground. And I think that's what these two bills do, is to move this program along in that direction.

You don't need to answer this one right now, Mr. Coddington, but my own view on the liability issue is, we need to learn more about it. My hope is, we can move forward with these two pieces of legislation that allow us to do the assessment and the mapping of the demonstration projects and have some time to figure out how we're going to deal with the more complicated issue of liability. And perhaps at some other time, you can help us figure out how we best approach this—the liability issue, because I do think it's an important aspect of what we have to deal with.

Thank you, Mr. Chairman.

The CHAIRMAN. Senator Domenici, did you want to go ahead and complete your questions, and then Senator Corker?

Senator DOMENICI. Oh, no, you go ahead, Senator.

Senator CORKER. You first.

Senator DOMENICI. All right, thank you very much. I'll go, quickly.

Mr. Hawkins, you just spoke of performance standards. And I think I heard you discuss a standard of generating electricity from a certain portion of low-carbon-emitting sources, then I heard you support a renewable portfolio standard on the Federal level. Where would nuclear, a form of energy that emits no carbon dioxide, fit into your panoply of standards—fit?

Mr. HAWKINS. Senator, we think that nuclear energy is a mature, proven technology. We think it has been the beneficiary of about four decades of Federal subsidies and incentives, and we don't, frankly, see a need for an additional round of subsidies and incentives. NRDC has no problem with nuclear power playing a role in this area, but we think it ought to be done on a level playing field, and don't see the need for additional incentives or requirements with respect to that technology, since it is a mature commercially-proven technology.

The one substantive thing that I will flag is the issue of proliferation. We do think that if the United States were to, sort of, embrace a nuclear renaissance, we should not be naive enough to expect that we're the only country that's going to want to do that. And what do we do with the prospect of 70 or 80 or 90 other countries around the world that say, "Us, too"? We see the difficulty we have with Iran today. If you have uranium enrichment processes in a country, it's very difficult to avoid dispersion and diversion of the—of these nuclear materials. So, we think that before we embrace a large-scale expansion of nuclear power, the world ought to develop a serious and effective nonproliferation regime.

Senator DOMENICI. Is wind energy a mature, proven form of energy? And would it fit into your standard?

Mr. HAWKINS. I would say that it is a junior partner to nuclear as to its maturity, and certainly as to its subsidies, Senator.

Senator DOMENICI. Current subsidies, it's coming along pretty well, because we set the pattern of giving them all the same 25 or 35, whatever it was. They all get granted. Nuclear costs more, so

it gets bigger, but it's 25, just like a windmill is 25. At least, we tried to do that. And I think we've succeeded, so far. Nobody's yanked the chain on this, thus far.

I had one other one, but I've misplaced it, and I'm sure the world will never know the difference.

[Laughter.]

Senator DOMENICI. And you're in good enough shape to go home. And my friend from Tennessee has a question and would like to ask it.

The CHAIRMAN. All right.

Senator Corker.

Senator CORKER. Thank you, Mr. Chairman.

Mr. Coddington, on the liability issues, I know Senator Salazar seemed to have a good point, just before he left the panel a minute ago, but are you concerned about liability as it relates to these pilot projects, the test projects? Are you concerned about people actually taking them on, per this new legislation, because of the liability?

Mr. CODDINGTON. I'm focused more from a commercial perspective, so I'm talking about commercial projects moving forward, either on a parallel track or maybe in an advance of an R&D agenda. So, I'm not speaking about the pilot projects. I think the pilot projects are important. My point was more that if the liability were to be clarified sooner rather than later, I think you would see commercial projects go forward sooner than people might expect.

Senator CORKER. I noticed, in your written testimony, you referred to the Norwegian model. Would you want to educate us a little bit as to what they are doing as it relates to the liability?

Mr. CODDINGTON. Well, they're in the early stages. And Norway, of course, just because of their system of government, that may not be the most relevant point of comparison. But they are looking at setting up a government corporation to effectively run and manage the sequestration piece of carbon injection. So, you could look at a U.S.-owned CO_2 storage corporation, for example. I don't know if that's the right approach. But there are other analogs. I mean, there's a Price-Anderson Act. You look at what was done with vaccines in the United States, where you set up a compensation fund of some kind. I mean, there are different forms of liability protection that might be more suitable to a U.S. model. But I do think there are answers out there.

Senator CORKER. I think we're about questioned out. I will ask the panel—we're going to be—I have 3 minutes and 14 seconds. Are there any salient points that you'd like to bring before us before we all depart?

Mr. HAWKINS. Well, Senator, at the risk of delaying your departure, I will just make a couple of quick comments on liability. The Texas example was mentioned. The concern that we have with this liability is that it may backfire, it may create a sense of lack of confidence in the public. Texas, for example, has assumed liability on the part of Texas, but, at the same time, the Texas public officials are going around saying that they're going to assert sovereign immunity, which means that nobody has the liability. They're taking the liability away from the private sector, but they've put it into a box, where they're going to assert sovereign immunity. If that's

the way the public thinks this is going to operate, that's not going to inspire confidence. There's also a market distortion issue.

This is going to be a technique for managing carbon emissions. It's going to compete against lots of other techniques—perhaps nuclear power, perhaps wind, perhaps solar. And if the Government picks up part of the tab of this mitigation measure, then doesn't that distort the market? And so, those are things to be thought about.

There's a difference between reliability and responsibility. There is a good case to be made that a government entity, 40, 50 years in the future, when these sites close, should bear a continuing responsibility. But the rules ought to be structured so that the full costs of operating that are borne by the private-sector decisionmakers that decide to use that technique. And we think that's entirely workable. It'll be factored in insurance policies, contracts. The private sector can handle this aspect of it, we believe.

Senator CORKER. What Senator Salazar referred to—and that is, letting this legislation move, going ahead and allowing these tests to take place, and let's learn a little bit more about what those liabilities are—is that sensible, or do you—are you thinking it's a more urgent type of issue?

Mr. HAWKINS. We think that the approach you just outlined is entirely sensible. We're injecting 35 million tons of CO_2 per year, with private operators, today in the United States. They've figured out, with contracts, insurance, how to handle that short-term risk. What about the long-term risk of very slow leakage? Well, I would submit that if anyone is seriously worried about the long term leakage of small amounts of CO_2 today, they ought to be much more concerned about the liability associated with the 100 percent of emissions that are coming out of smokestacks today. Those emissions are going to be up there for the next 150 years. So, I have a hard time seeing that as a serious issue.

Senator CORKER. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you all for your testimony. I think it's been very useful, and we will try to take your suggestions to heart and move forward with this legislation.

So, that concludes the hearing. Thank you.

[Whereupon, at 4 p.m., the hearing was adjourned.]

APPENDIXES

APPENDIX I

Responses to Additional Questions

DEPARTMENT OF ENERGY,
CONGRESSIONAL AND INTERGOVERNMENTAL AFFAIRS,
Washington, DC, May 9, 2007.

Hon. JEFF BINGAMAN,
Chairman, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR MR. CHAIRMAN: On April 16, 2007, Thomas D. Shope, Acting Assistant Secretary, Office of Fossil Energy, testified regarding S. 731, National Carbon Dioxide Storage Capacity Assessment Act of 2007, and S. 962, Department of Energy Carbon Capture and Storage Research, Development, and Demonstration Act of 2007.

Enclosed are the answers to 36 questions that were submitted by Senators Domenici, Dorgan, Salazar and you for the hearing record. The remaining four questions are being prepared and will be forwarded to you as soon as possible.

If we can be of further assistance, please have your staff contact our Congressional Hearing Coordinator, Lillian Owen, at (202) 586-2031.

Sincerely,

ERIC NICOLL,
Acting Assistant Secretary.

[Enclosures.]

QUESTIONS FROM SENATOR BINGAMAN

Question 1. In the advent that there are problems with large-scale project start up due to liability concerns, is it your opinion that the DOE should take on the liability of the large-scale demonstration projects? If the DOE is not the correct agency, which company or agency should take on the liability for these projects?

Answer. The Department of Energy cannot identify the organization or agency that should assume this liability. This is an issue that must be resolved by the property and mineral rights owners at the site of the project. These entities could include private landowners, industry partners, private insurance companies, state governments, and federal agencies that manage the public lands and mineral resources of the United States.

Question 3. In Mr. Hawkins testimony, he states that there are areas around the US that were not assessed, while other testimony provided states that those areas in the US where data is not available represents areas where geological storage potential is slim. Would it be helpful to obtain field confirmation, in the form of drill wells and well data, to determine whether formations are suitable for carbon dioxide storage in those areas?

Answer. It would be helpful, but not necessary, to gather additional physical data to demonstrate that adequate capacity exists to store CO_2 throughout the United States. This data would likely confirm that the storage capacity reported in the first edition of the Carbon Sequestration Atlas of the United States and Canada exists and is adequate to mitigate hundreds of years of future CO_2 emissions. DOE suggests that resources should be used to implement large-scale sequestration tests that will demonstrate that the capacity and injectivity rates are adequate for full-scale development of carbon capture and storage projects in the different geologic formations throughout the United States. The implementation of these tests will result in new physical data on the storage formations as well as provide results from

the long-term injection operations that will measure effects on the target formations, the feasibility of monitoring technologies, integrity of cap rock, and well construction techniques. The results of these field tests will be used to develop best practice manuals for future commercial projects. It is possible that further evaluation of geological storage capacity may reveal additional opportunities for CO_2 storage.

Question 5. As Mr. Coddington addressed in his testimony, will the recent US Supreme Court ruling that the EPA has the authority, under the Clean Air Act, to enact limits on carbon dioxide (CO_2) emissions (as an air pollutant) carry over to injection of carbon dioxide into geologic storage sites? Will the treatment of CO_2 as a waste pollutant versus a commodity that can be used for enhanced oil recovery or other uses pose a significant hindrance to rapid deployment of large-scale demonstration projects?

Answer. This ruling is not expected to impact the development of large volume sequestration tests. Permitting of carbon dioxide injection projects currently falls under the jurisdiction of the Safe Drinking Water Act Underground Injection Control Program. The U.S. Environmental Protection Agency (EPA) recently released guidance to the regions and states clarifying that the sequestration projects being developed in deep saline formations should be permitted as Class V (experimental) injection wells. EPA has also suggested that carbon sequestration projects involving enhanced oil recovery or coalbed methane recovery should be permitted as Class II injection wells.

Question 6a. You recommended that section 963(c)(2)(B)(vii) of the Energy Policy Act, as proposed to be added by S. 962, be "clarified to determine if this provides the Secretary with the authority for DOE to undertake liability for large-scale testing should this become an issue that delays or halts large-scale testing." (a) Please identify the potential types of risk posed by the proposed carbon sequestration testing program that could give rise to liability.

Answer. It is important to realize that although risks may exist they can be mitigated through proper site selection, operation, and closure of the storage projects. Large scale sequestration projects will include the usual risks associated with the construction and operation of a project. Employees and contractors will be working on a physical site. In the case of pilot scale projects, trucks carrying CO_2 will be on site. These are not risks unique to carbon dioxide storage projects. The potential, but unlikely, risks associated with storage include potential leakage, accumulation of CO_2 at the earth's surface, or significant release to the atmosphere. The pathways for leakage potentially include the handling of CO_2 en route to the injection pump, problems with the well, migration through faults or unidentified abandoned wells, or migration through natural fractures in the caprock.

Question 6b. What is the maximum amount of liability that could arise out of each type of risk?

Answer. The amount of liability is greatly influenced by the specific features of the site. It will depend on the hazards that are present, the probability that an incident will occur, and the potential impact it will have. Therefore, it is very difficult to assess the maximum amount of liability that would arise from each risk.

Question 6c. How do the nature and likelihood of the risks and the potential liabilities associated with the proposed carbon sequestration testing program compare with the potential risks and liabilities traditionally undertaken by the Department's contractors (including both indemnified and non-indemnified activities).

Answer. As previously stated, beyond the usual risks associated with the construction and operation of a project, it is difficult to compare risks and liabilities without knowing the specific sites of the proposed projects.

Question 6d. To what extent have commercial activities involving the geologic injection of carbon dioxide, whether for storage or enhanced oil recovery, given rise to liability in the past.

Answer. We are not aware of any commercial activities involving the geologic injection of CO_2 that have given rise to liability in the past.

Question 6e. To what extent has the potential for liability hampered or precluded commercial geologic injection activities?

Answer. It is important to recognize that potential liability is one of many factors that industry must consider when determining whether to develop commercial carbon sequestration activities. There exist no active commercial sequestration projects in the United States since it is not economically viable to develop these projects. The Department recognizes that long-term liability will be an issue that will need to be addressed in the future.

Question 6f. To what extent has the Department been unable to find willing contractors to participate in its existing Regional Partnerships program because of liability concerns?

Answer. The Department has not experienced a problem finding contractors willing to participate in the development of large volume sequestration projects with the Regional Partnerships. Several companies have expressed their intentions to assume the operational and long-term liability associated with the projects and/or work with states to share the responsibilities.

Question 6g. To what extent does the Department believe it will need to indemnify future contractors for them to be willing to participate in the program proposed in S. 962?

Answer. It is our current understanding that DOE can provide funding to cover insurance products during the operation of the projects but cannot assume any long-term liability.

Question 6h. To what extent can contractors obtain financial protection against these potential liabilities from private sources, either now or in the foreseeable future?

Answer. Insurance policies exist for a number of industries that are analogous to carbon storage projects. These include operations related to carbon dioxide capture, pipeline transport, and injection for enhanced oil recovery operation; natural gas transport and injection at natural gas storage facilities; as well as acid gas storage operations. The Regional Partnerships and other organizations have begun to engage the insurance industry to determine the information needed to develop policies to cover liability during the operational period of the large-scale storage projects. It is reasonable to assume that the contractors will be able to obtain policies from private insurance companies or through corporate insurance to protect them against potential liabilities.

Question 6i. What, if any, authority does the Department now have to indemnify its contractors for potential liabilities arising from non-radiological hazards posed by work undertaken for the Department?

Answer. As indicated in the previous response, the Department of Energy does not have the authority to indemnify its contractors against liabilities under awards made through cooperative agreements.

Question 6j. What, if any, additional indemnification authority is the Department seeking?

Answer. The Department is not seeking additional indemnification authority at this time.

QUESTIONS FROM SENATOR DOMENICI

Question 1. We learned from a recently released Duke University study that much of eastern Virginia and all of North Carolina, South Carolina, and Georgia are devoid of potential carbon dioxide sequestration sites. S. 731(the National Carbon Dioxide Storage Capacity Assessment Act of 2007) calls for a survey of potential carbon dioxide storage sites.

In your estimation, would it be wise to include an examination of the potential carbon dioxide pipeline rights-of-way in the analysis called for in S. 731?

Answer. Significant work on CO_2 pipeline right-of-ways has been completed by the Regional Partnerships. The Characterization work completed by the Regional Partnerships has included an examination of the existing pipelines (carbon dioxide and natural gas) and other rights-of-way in the United States. The geospatial data on pipelines is considered sensitive information and its distribution is restricted due to federal security requirements. The data is contained in the National Carbon Sequestration Database and Geographic Information System (NATCARB) online Atlas, but is not displayed in either the Carbon Sequestration Atlas or the NATCARB web-based Atlas due to these restrictions. Several partnerships have assessed the need to develop new CO_2 pipelines that would connect the existing pipeline infrastructure and develop a system to connect sources to regional sinks. In addition, geospatial data on rights-of-way along transmission lines, railroad, and roads have been included in the NATCARB online Atlas as potential routes for future CO_2 pipelines. Pipeline tools have also been developed for NATCARB through a cooperative agreement with Massachusetts Institute of Technology that can be used to design pipeline routes and estimate the construction costs of pipeline needs to connect sources of CO_2 with regional sinks.

Question 2. We learned from a recently released Duke University study that much of eastern Virginia and all of North Carolina, South Carolina, and Georgia are devoid of potential carbon dioxide sequestration sites. S. 731 (the National Carbon Dioxide Storage Capacity Assessment Act of 2007) calls for a survey of potential carbon dioxide storage sites.

Would a survey and map of the existing pipeline rights-of-way help facilitate locating sequestration sites?

Answer. A map of existing pipeline rights-of-way could be beneficial to future project developers. It is imperative that the pipelines be sized to accommodate existing and future power plants. It is also important to note that this information already exists in the NATCARB online Atlas but is not currently displayed due to restrictions on the data. With some additional effort, this map could be developed based on the existing rights-of-way that are included in the database.

Question 3. We learned from a recently released Duke University study that much of eastern Virginia and all of North Carolina, South Carolina, and Georgia are devoid of potential carbon dioxide sequestration sites. S. 731 (the National Carbon Dioxide Storage Capacity Assessment Act of 2007) calls for a survey of potential carbon dioxide storage sites.

Would it be wise to include a survey and map of where our current and planned coal-fired power plants are?

Answer. The Department is willing to develop this map based on the data that has been collected by the Regional Partnerships and available through the National Carbon Sequestration Database and Geographic Information System (NATCARB) online Atlas. The Regional Partnerships have spent over two years collecting information on existing and future coal-fired power plants from federal, state, industry, and site surveys. In many instances, the partnerships were responsible for correcting the information in several databases to refine location and CO_2 emissions data. The Regional Partnerships geographic information systems have CO_2 emission point source data that accounts for over 4 billion tons of CO_2 emissions in the United States and Canada.

Question 4. We learned from a recently released Duke University study that much of eastern Virginia and all of North Carolina, South Carolina, and Georgia are devoid of potential carbon dioxide sequestration sites. S. 731 (the National Carbon Dioxide Storage Capacity Assessment Act of 2007) calls for a survey of potential carbon dioxide storage sites.

How difficult would it be for the United States Geological Survey to include a pipe-line right-of-way survey and a coal-fired power plant location survey in the studies called for in S. 731?

Answer. The development of a pipe-line right-of-way and coal-fired power plant survey would require very little effort on behalf of United States Geological Survey (USGS) since most of the work has already been completed by the Department of Energy (DOE), the Regional Partnerships, and the National Carbon Sequestration Database and Geographic Information System (NATCARB). DOE is willing to work with the USGS to support the development of this survey under S. 731 to ensure that the information used to develop these maps reflects the over two years of effort by the Partnerships to compile and update the data from existing public databases, industry partners, and site surveys.

Question 5. We learned from a recently released Duke University study that much of eastern Virginia and all of North Carolina, South Carolina, and Georgia are devoid of potential carbon dioxide sequestration sites. S. 731 (the National Carbon Dioxide Storage Capacity Assessment Act of 2007) calls for a survey of potential carbon dioxide storage sites.

Would it be possible to also include an assessment of potential environmental risks of running carbon dioxide pipelines from the coal-fired power plants to the potential repositories?

Answer. The transport of CO_2 via pipeline is a common industry practice where approximately 1,200 miles of pipeline currently transport over 70 millions of tons of CO_2 per year across portions of the Southwest, Wyoming, North Dakota, and the Southeast primarily for enhanced oil recovery. These pipelines are regulated by the U.S. Department of Transportation and have a historically low incidence of risk. A report on the risks of constructing a CO_2 pipeline could be developed, but would have to focus on the generic risks. This would not replace the need to conduct a site specific environmental assessment when a company proposes to develop a CO_2 pipeline for a commercial storage project.

Question 6. S. 731 calls for the agencies to develop the methodology and to complete a national assessment of geological storage capacity for carbon dioxide in a saline formation, unmineable coal seam, or oil or gas reservoir capable of accommodating a volume of industrial carbon dioxide. During an earlier hearing on the MIT report, *The Future of Coal in a Carbon Constrained World,* one witness suggested that half of the United States coal reserves are currently considered unmineable.

Can you tell me what percent of our country's coal fields were considered unmineable in 1900?

Answer. We estimate are not aware of any studies of coal production technologies or available coal reserves in 1900. Current coal reserve estimates are based on coal mining technologies that were available in the 1970s. However, these estimates are

likely to be greater than current estimates of unmineable coal seams due to technological advances in coal mining technologies.

Question 7. S. 731 calls for the agencies to develop the methodology and to complete a national assessment of geological storage capacity for carbon dioxide in a saline formation, unmineable coal seam, or oil or gas reservoir capable of accommodating a volume of industrial carbon dioxide. During an earlier hearing on the MIT report, The Future of Coal in a Carbon Constrained World, one witness suggested that half of the United States coal reserves are currently considered unmineable.

Of those considered unmineable in 1900, how many have been developed and mined 100 years later?

Answer. Without the assessment asked for in the previous question, it is not possible to answer this question without a full study of the coal mining technologies available in 1900.

Question 8. S. 731 calls for the agencies to develop the methodology and to complete a national assessment of geological storage capacity for carbon dioxide in a saline formation, unmineable coal seam, or oil or gas reservoir capable of accommodating a volume of industrial carbon dioxide. During an earlier hearing on the MIT report, The Future of Coal in a Carbon Constrained World, one witness suggested that half of the United States coal reserves are currently considered unmineable.

Can you estimate what percent of our counties' coal resources will be considered unmineable 100 years from now?

Answer. Without a thorough study of the issue, it is difficult to predict what percentage of presently unmineable coals will be considered mineable in 100 years. We are unaware of any such study to date. Moreover, the study would have to project likely advancements in coal mining technologies that will be made over that time; this is a difficult task.

Question 9. S. 731 calls for the agencies to develop the methodology and to complete a national assessment of geological storage capacity for carbon dioxide in a saline formation, unmineable coal seam, or oil or gas reservoir capable of accommodating a volume of industrial carbon dioxide. During an earlier hearing on the MIT report, The Future of Coal in a Carbon Constrained World, one witness suggested that half of the United States coal reserves are currently considered unmineable.

If we do inject large quantities of carbon dioxide into these unmineable coal seams, how might that affect our ability to mine them in the future?

Answer. The United States has extensive coal resources. Theoretically, CO_2 could be stored in a coal seam, which could then be mined eventually. However, it is important to note that the Regional Partnerships have been investigating the injection of CO_2 into deep unmineable coal seams that are typically twice as deep as coals currently defined as unmineable. Therefore, it is very unlikely that these very deep coals will ever be mined.

Question 10. There have been a number of questions and concerns about liability for storing carbon dioxide in long-term repositories.

How will you assess the potential impact or risk of storing this carbon dioxide to other mineral deposits above or near these injection sites?

Answer. The Department of Energy will be working with the large-scale project developers to deploy a full suite of measurement technologies to monitor the fate of the CO_2, which is injected into the storage formations to ensure that the CO_2 does not migrate to the overlying formations through the caprock along faults, fracture, or well bore penetrations. This will include using the following monitoring technologies, which will be used to monitor the CO_2 in storage formations and through possible leakage pathways in the overlying geologic stratum: geophysical methods, water chemistry analyses, tracers, microgravity, soil gas analysis, remote sensing, and mechanical integrity testing of the injection well(s). The projects will be required to conduct a baseline characterization where the data can be used to define the potential concerns that will need to be monitored during the injection and closure operations.

Question 11. There have been a number of questions and concerns about liability for storing carbon dioxide in long-term repositories.

How will you assess the potential impact of storing, and potential leakage of, this carbon dioxide into ground water and its impact on water rights above or near these injection sites?

Answer. Some of the large-scale sequestration projects selected in the United States will be required to assess the potential impact to water rights and ensure that the injection into deep saline formation is secure and will not impact overlying drinking water. The projects will be required to conduct a rigorous characterization of the project site to demonstrate that the storage formation has adequate capacity and injectivity and that overlying seals can contain the CO_2 indefinitely. DOE will work with the large-scale project developers to deploy a full suite of measurement

technologies to monitor the fate of the CO_2, which is injected into the storage formations to ensure that the CO_2 does not migrate to the overlying formations through the caprock along faults, fracture, or well bore penetrations. This will include using the following monitoring technologies, which will be used to monitor the CO_2 in storage formations and through possible leakage pathways in the overlying geologic stratum: geophysical methods, water chemistry analyses, tracers, microgravity, soil gas analysis, remote sensing, and mechanical integrity testing of the injection well(s). The projects will be required to conduct a baseline characterization where the data can be used to define the potential concerns that will need to be monitored during the injection and closure operations.

Question 12. There have been a number of questions and concerns about liability for storing carbon dioxide in long-term repositories.

How will you assess the potential for this carbon dioxide to somehow lubricate known and unknown faults in or near the injection sites?

Answer. In the first stage of the large-scale storage test, the project will characterize the sites using well bore testing and geophysical surveys to identify all known and potential faults and fractures that might exist. The projects will be required to avoid active faults where the fault may not be sealed and there is an increased risk of leakage through the fault. Many inactive faults act as seals that create structural traps where oil and gas deposits accumulate. These may actually serve as a good site for carbon sequestration projects. Historically, these sites have been developed for oil and gas production and may be preferred opportunities to store large amounts of CO_2. Analysis of the fault structure, physical integrity, and chemical composition of the caprock will be evaluated to ensure that the CO_2 will not migrate through the fault. In addition, the project will be required to operate at safe injection pressures.

Question 13. There have been a number of questions and concerns about liability for storing carbon dioxide in long-term repositories.

How will you estimate and discuss the potential damage from earthquakes that could be facilitated by the lubrication of faults in or near the injection sites.

Answer. As discussed in the response to question 12, the risk of lubricating an inactive fault that could cause earthquakes is negligible when the site characterization and injection operations are conducted appropriately.

Question 14. The Department of Energy and the U.S. Geological Survey share responsibility for research related to site selection, monitoring, and verification of candidate carbon sequestration sites.

Could each of you describe, in your own view, how the responsibilities should be divided between your agencies?

Answer. The Department of Energy (DOE) has characterized the United States and Canada's potential to store CO_2 emissions in deep geologic formations. This has been accomplished through the Regional Partnerships efforts working with federal, local, and industry partnership to assemble massive geographic information systems, which represent a resource that did not previously exist. DOE will continue this characterization effort throughout the Regional Partnership projects as they collect additional data, incorporate results from field test projects, and refine the methodology used to estimate storage capacity. DOE believes that considerable effort has been expended through the partnerships. We would like to continue this effort and to continue to fully engage the U.S. Geological Survey (USGS) as a partner as we refine the data and methodology. DOE will continue to develop an Atlas of the United States based on the refinements made to the data collected by the Partnerships. We believe that the USGS could help guide the next version of the methodology that will be used to estimate capacities in the United States. DOE would also seek USGS counsel on the organization of future versions of the Atlas. DOE believes that the USGS could provide substantial support on gathering data and providing information on federal lands to the Regional Partnerships.

Question 15. The Department of Energy and the U.S. Geological Survey share responsibility for research related to site selection, monitoring, and verification of candidate carbon sequestration sites.

How can the Federal government work most effectively with the State geological surveys?

Answer. The Regional Partnerships are collaborating with many of the Geologic Surveys in the 41 States that are part of the Regional Partnerships Program. The Department of Energy worked collaboratively with the state geologic surveys to develop the skills and knowledge about carbon sequestration technologies so they are in a position to represent their state's opportunities for carbon sequestration. This model provides the states with the opportunity to build a carbon storage industry within the states since the expertise resides with the surveys.

QUESTIONS FROM SENATOR DORGAN

Question 1. Mr. Shope, my understanding is that enhanced oil recovery is the major form of commercial scale CO_2 sequestration activities being pursued today. I also understand that underground retired oil and natural gas reservoirs and old coal seams are being studied as potential storage areas for CO_2.

My home state has both. We have the largest commercial scale demonstration project for Enhanced oil recovery (EOR) in the United States. We remove the Cot at the front end of a coal gasification process and pipe it 205 miles to the Weyburn oil fields in Alberta, Canada to extend the life of marginal oil wells. We also have a robust oil and gas field in the Williston Basin.

How much of the research by the DOE regional partnerships is focused on the potential for near-term EOR and storage in used oil, natural gas, and coal seams?

Answer. The Regional Partnership Characterization Phase I effort determined the potential of depleted oil and gas and coal seams to store CO_2 and produce oil and gas. During Phase II, the Department of Energy (DOE) is supporting 9 depleted oil fields, 5 unmineable coal seams, and 1 depleted gas field carbon storage tests to determine the storage potential and amount of resources that could be recovered. During the large-scale Deployment Phase, the DOE may support large-scale sequestration projects that involve EOR and/or enhanced coalbed methane (ECBM) as long as the storage potential in these types of sinks is significant to the region.

However, since these areas are better understood and more likely to have commercial benefits than saline aquifers, DOE will target Federal funding at those research questions least likely to be pursued by commercial interests without Federal help. DOE is committed to promoting sequestration with EOR and/or ECBM in the marketplace since we understand that these opportunities offer near term solutions to mitigate carbon dioxide emissions and build the necessary infrastructure.

Question 4. Technology will play a key role in the implementation and success of Carbon Capture and Storage technology.

Mr. Shope, what is the Administration's long term technology strategy to expedite the development of commercial scale carbon capture and storage technologies that will help us achieve near zero emissions fossil fueled power plants?

Answer. The Department of Energy's long-term strategy is to accelerate large-scale field tests and to fully support the FutureGen project, both of which in combination are aimed at addressing the geologic storage aspect of CO_2 as well as low-cost, integrated capture of CO_2 from fossil fueled power plants.

QUESTIONS FROM SENATOR SALAZAR

Question 1. Did DOE utilize a common set of standards or methodology in the Carbon Sequestration Atlas characterization efforts? If so, how was the methodology developed and reviewed across the DOE Regional Partnerships? Was the quality of the assessments done by the different Partnerships the same? Did all the Partnerships have similar data and expertise?

Answer. Yes, the regional partnerships used common methodology, which was developed by a capacity subgroup organized by the Department of Energy (DOE) and Regional Partnerships. This methodology was developed during a series of working group meetings during which the team reviewed and vetted the methods and assumptions made by all the partnerships, and concurred on an acceptable methodology across all partnerships. The methodology, which was used for the first edition of the Carbon Sequestration Atlas of the United States is available on the web at:

http://www.net1.doe.gov/publications/carbon__seq/atlas/Appendix%20A.pdf.

The quality of the assessments completed by the Partnerships was similar. The assessment required that many regions develop new electronic data from paper well logs and obtain data from industry partners, which are not available to the general public. Eventually, the partnerships were able to develop a consistent set of data across the partnerships and use their shared expertise to estimate regional storage capacities.

Question 2. Is the documentation of key parameters and risk factors transparent enough that an outside entity could review the Atlas, and understand what was done and how it was done and what data were used? Where is this information available? Is it on a website?

Answer. We believe that the key parameters and risk factors in the Atlas have been clearly documented. The key parameters are described in the methodologies document, which was published with the Atlas. These steps will be further described in the technical report that the Regional Partnerships are required to develop under their existing cooperative agreements with the Department of Energy (DOE). The technical reports are published at the end of each project, which will be submitted

to DOE at the end of the Phase II cooperative agreements. The methodologies document can be accessed at:

http://www.net1.doe.gov/publications/carbon__seq/atlas/Appendix%20A.pdf.

Question 3. What improvements to the characterization process would you propose? Where would you like to see more investment?

Answer. The Department of Energy (DOE) will be reconvening the capacity subgroup in the near future to begin work on refining the capacity assessment methodology in preparation for the next version of the Carbon Sequestration Atlas. As the Regional Partnerships work in the field to demonstrate the capacity of the regions, new wells will be drilled providing information on formations that was not previously available and results of the field tests will help to refine the assumption in the capacity methodology. DOE will continue to add industry partners, convert paper data to digital format, and further develop relationships with state and regional groups that can provide additional information on geological formations throughout the United States. Support of the large-scale sequestration tests is critical to assessing the feasibility of the storage opportunities identified during the initial characterization.

Question 4. Did the Department's budget provide sufficient funding for a complete national assessment or was the assessment in the Atlas limited to selected sites?

Answer. We believe that the Department adequately funded this effort, which resulted in the Carbon Sequestration Atlas released in the past month, wherein the assessment demonstrates that geologic carbon sequestration opportunities exist throughout the United States and Canada. The basins assessed during this characterization effort could store hundreds of years of future CO_2 emissions while producing additional oil and gas, which would otherwise be unrecoverable. Additional effort went into characterization of specific target formations, such as the oil and gas field and coal seams where extensive data exists. Some additional characterization will be completed on these fields as additional data from industry partnerships is provided to the Partnerships. Saline formations were assessed where data was available. The Partnerships have been able to collect additional information from industry partners and piggyback drilling operations that have shown that other saline formations may offer significant opportunities for storage that would otherwise have been ignored. The Regional Partnerships will continue their characterization efforts as they gather additional data and results from their field tests.

Question 5. Explain why the DOE Regional Sequestration Partnerships do not cover all fifty states.

Answer. The Regional Partnerships were selected through a competitive solicitation in September of 2003. At the time of the awards, the partnership consisted of 33 states, 2 Indian Nations, and 2 Canadian Provinces. Since then, the DOE and the Regional Partnerships have added 8 new states and 2 Canadian Provinces to the program. The Partnerships now include all the major geologic basins and potential sinks in the United States. As shown by the Carbon Sequestration Atlas, the states in the New England area are underlain principally by bedrock and have virtually no geologic storage potential. The National Carbon Sequestration Database and Geographic Information System (NATCARB) has included data for the Northeast CO_2 point sources and right-of-way for pipelines, transmission lines, and roadways understanding that these sources may need to be connected to storage sites. In addition, additional states can join the Regional Partnerships at any time. For example, New York has just recently joined (January 2007).

Question 6. Explain what the DOE Regional Sequestration Partnerships have done to characterize the relative attractiveness or economic viability of the known potential carbon dioxide storage sites in the United States. If this information is available, is it on a website?

Answer. The Regional Partnerships worked together to assess the storage capacity as represented in the Carbon Sequestration Atlas. This is available at the following website:

http://www.net1.doe.gov/publications/carbon__seq/atlas

In addition, each of the Regional Partnerships has conducted in-depth assessments of certain target formations in their regions that have significant opportunities for potentially economically viable development. Some of this information is contained in the final report and products from their Characterization Phase (Phase I) projects while some assessments have been completed under their Validation Phase (Phase II) projects and will be published as part of their technical reports due at the end of the projects. The reports from the Characterization Phase can be downloaded at the following website:

http://www.net1.doe.gov/technologies/carbon__seq/partnerships/phaseI/workproducts__table.html.

DEPARTMENT OF ENERGY,
CONGRESSIONAL AND INTERGOVERNMENTAL AFFAIRS,
Washington, DC, May 22, 2007.

Hon. JEFF BINGAMAN,
Chairman, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR MR. CHAIRMAN: On April 16, 2007, Thomas D. Shope, Acting Assistant Secretary, Office of Fossil Energy, testified regarding S. 731, National Carbon Dioxide Storage Capacity Assessment Act of 2007, and S. 962, Department of Energy Carbon Capture and Storage Research, Development, and Demonstration Act of 2007.

Enclosed are the answers to four questions that were submitted by you and Senator Dorgan to complete the hearing record.

If we can be of further assistance, please have your staff contact our Congressional Hearing Coordinator, Lillian Owen, at (202) 586-2031.

Sincerely,

ERIC NICOLL,
Acting Assistant Secretary.

[Enclosures.]

QUESTIONS FROM SENATOR BINGAMAN

Question 2. In your testimony you state that higher funding levels are necessary to get these large-scale demonstration projects started. What funding levels would you recommend to fast-track one or two large demonstration projects?

Answer. The Administration intends to undertake four large-scale demonstration projects with the funding allocated in the operating plan in FY 2007 and requested in FY 2008 under the carbon sequestration program. Funding levels to support seven (as opposed to four) large volume sequestration tests that could be required under S. 962 would need to be offset with cuts made elsewhere. The funding requirements for each of these field tests are highly site-specific. The funding in the outyears would depend on the schedules for each of the large-scale tests.

Question 4. After hearing all of today's testimony, it is important to consider how the liability surrounding large-scale CO_2 injection will impact the deployment of the projects we've been discussing. Would the liabilities that were discussed today be better handled at the Federal or State level? The testimony today sends a bit of a mixed message as to which level is better suited to employ liability management.

Answer. Under the Federal Acquisition Regulations the Department of Energy is restricted from taking on the liability from projects awarded under cooperative agreements. Unless a change to these Federal regulations is made, the organizations awarded the large-scale sequestration tests will need to determine who will accept the liability associated with the development of these projects. Instruments exist within the insurance industry to accept the operational liabilities associated with CO_2 storage projects. We also know that the states of Texas and Illinois have taken steps to assume the liability of the long-term storage of CO_2 associated with the FutureGen facility.

QUESTIONS FROM SENATOR DORGAN

Question 2. I believe we will continue to use coal and other fossil fuels along with renewables into the future. However, I also believe we need to find cleaner ways to use coal and other fossil fuels.

Mr. Shope, do you support the authorization funding in the legislation at the levels that they have been authorized for FY08 and FY09? Are these adequate levels to stay on track with the administrations policy direction for carbon capture and storage?

Answer. The funding levels proposed in the President's budget are the optimum level for the available resources; provision of additional resources would require cuts in other areas that the President's budgeting processes deemed to be higher priority. The funding levels are adequate for the goals identified in the FY 2008 Congressional Budget Request.

Question 3. Mr. Shope, as you are aware, the clean coal program within the DOE Office of Fossil Energy is like a three-legged stool. The first leg is the basic research program which includes the carbon capture and storage program. The second leg is the clean coal power initiative demonstration program. The third leg is the

FutureGen project. It is becoming apparent that the Administration has prioritized the FutureGen project to the detriment of the other two legs of the stool.

How are we going to be able to stand up on the stool if programs that help fund carbon capture and storage are not adequately funded?

Answer. The Department of Energy is committed to maintaining a balanced coal research portfolio necessary to support the goal of achieving near-zero atmospheric emissions coal, including carbon capture and storage. We will continue to work to ensure that we have a robust carbon sequestration program as part of a balanced research program.

RESPONSES OF THE DEPARTMENT OF THE INTERIOR TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. Given that you have indicated that the time frame specified in the bill (S. 731) for the storage capacity resource assessment is too constrictive for a comprehensive study, what is your estimate for the time needed to complete such an analysis as described in the bill?

Answer. The U.S. Geological Survey (USGS) has determined that it would likely take at least one year to develop an assessment methodology for geologic carbon sequestration and submit that assessment methodology for independent, peer review. Once the review process is done, and any changes are made to the methodology, it would likely take at least three years to complete a national assessment of geologic storage capacity for carbon dioxide. During that time frame, the USGS would also identify significant data gaps and outstanding research issues that would best reduce uncertainty in subsequent national assessments. Most of these issues would most likely be related to greater understanding of the long term integrity of carbon dioxide storage in geologic reservoirs, especially in saline aquifers. During the development and implementation of the assessment methodology, the USGS would consult and collaborate with other organizations as appropriate, including the state geological surveys, the Department of Energy, the Environmental Protection Agency, and the land and resource bureaus of the Department of the Interior, to ensure to the maximum extent possible the efficiency, effectiveness, and coordination of carbon sequestration efforts across the Federal government. As noted in our statement for this hearing, many states already have some storage capacity data already developed, most of which is compiled in the National Carbon Sequestration Atlas published by the Department of Energy. The USGS would plan to use this information to inform its work on a resource assessment. It is also important to recognize that, if authorized, such a comprehensive national inventory would need to compete among many other science research priorities for funding, and this could affect the eventual timelines for completion of a full inventory.

Question 2. In Mr. Hawkins testimony, he states that there are areas around the US that were not assessed, while other testimony provided states that those areas in the US where data is not available represents areas where geological storage potential is slim. Would it be helpful to obtain field confirmation, in the form of drill wells and well data, to determine whether formations are suitable for carbon dioxide storage in those areas?

Answer. It could be useful to obtain field data for those areas to help determine the presence and suitability of geologic formations for carbon dioxide storage and sequestration. However, it may not be productive to perform such field work in areas that are known low potential areas.

Question 3. After hearing all of today's testimony, it is important to consider how the liability surrounding large-scale CO_2 injection will impact the deployment of the projects we've been discussing. Would the liabilities that were discussed today be better handled at the Federal or State level? The testimony today sends a bit of a mixed message as to which level is better suited to employ liability management.

Answer. The liability issues are outside the USGS's purview, and we respectfully defer to the Department of Justice as to the Administration's legal view of that issue.

Question 4. As Mr. Coddington addressed in his testimony, will the recent US Supreme Court ruling that the EPA has the authority, under the Clean Air Act, to enact limits on carbon dioxide (CO_2) emissions (as an air pollutant) carry over to injection of carbon dioxide into geologic storage sites? Will the treatment of CO_2 as a waste pollutant versus a commodity that can be used for enhanced oil recovery or other uses pose a significant hindrance to rapid deployment of large-scale demonstration projects?

Answer. As noted in the above response, discussion of the ramifications of recent Supreme Court decisions is outside the USGS's purview, and we respectfully defer

to the Department of Justice as to the Administration's view of that issue. Similarly, speculation as to the impacts on deployment of projects on differing treatment of carbon dioxide is more appropriately addressed by entities with management or regulatory authority such as the Environmental Protection Agency or with expertise in advanced technology deployment projects, such as the Department of Energy.

RESPONSES OF THE DEPARTMENT OF THE INTERIOR TO QUESTIONS FROM SENATOR DOMENICI

We learned from a recently released Duke University study that much of eastern Virginia and all of North Carolina, South Carolina, and Georgia are devoid of potential carbon dioxide sequestration sites. S. 731(the National Carbon Dioxide Storage Capacity Assessment Act of 2007) calls for a survey of potential carbon dioxide storage sites.

Question 1. In your estimation, would it be wise to include an examination of the potential carbon dioxide pipeline rights-of-way in the analysis called for in S. 731?

Answer. No, not in the actual resource assessment itself. A resource assessment, although used for a variety of purposes and analyses, such as infrastructure development, should be carried out initially as a stand-alone assessment. Subsequent to the assessment, or parallel to the assessment, but conducted by another organization whose purview includes pipeline rights-of-way, such an analysis could help policy makers and land and resource managers with the developmental stage of carbon dioxide sequestration.

Question 2. Would a survey and map of the existing pipeline rights-of-way help facilitate locating sequestration sites?

Answer. Although conducting such a survey is outside the USGS's purview, it is logical that a survey and map of the existing pipeline rights-of-way could help facilitate locating sequestration sites. This could also aid in the economic analysis of carbon dioxide sequestration projects and help illustrate where there might be short-term opportunities for carbon dioxide sequestration projects.

Question 3. Would it be wise to include a survey and map of where our current and planned coal-fired power plants are? (answer provided at number 4)

Question 4. How difficult would it be for the United States Geological Survey to include a pipe-line right-of-way survey and a coal-fired power plant location survey in the studies called for in S. 731?

Answer. The USGS has a database of power plants provided by the Environmental Protection Agency (EPA) that includes coal-, gas-, oil-, and biomass-fired plants. If another group were to provide the locations of planned coal-fired power plants and the pipeline right-of-way data in a Geographic Information Systems (GIS) format, it would not be difficult to incorporate this information in the studies as well. These data are the responsibility of others (e.g., the Federal Energy Regulatory Commission (FERC), the Department of Energy (DOE), EPA, etc.); however, USGS could incorporate the data should that data be provided by the appropriate organizations.

Question 5. Would it be possible to also include an assessment of potential environmental risks of running carbon dioxide pipelines from the coal-fired power plants to the potential repositories?

Answer. This is a secondary exercise to the resource assessment itself, but one that could be done by other management or regulatory agencies, such as those within Department of the Interior, the U.S. Forest Service, Department of Energy, or EPA, with responsibility for conducting environmental evaluations. This analysis might be run by one or more of these agencies in parallel to the resource assessment done by the USGS.

S. 731 calls for the agencies to develop the methodology and to complete a national assessment of geological storage capacity for carbon dioxide in a saline formation, unmineable coal seam, or oil or gas reservoir capable of accommodating a volume of industrial carbon dioxide. During an earlier hearing on the MIT report, The Future of Coal in a Carbon Constrained World, one witness suggested that half of the United States coal reserves are currently considered unmineable.

Question 1. Can you tell me what percent of our country's coal fields were considered unmineable in 1900?

Answer. It is very difficult to estimate the number of unmineable coal beds in 1900 because what constitutes an unmineable coal bed has changed over time. Further, usually only mineable coal beds are evaluated, making any evaluation of mineable to unmineable beds very difficult.

Question 2. Of those considered unmineable in 1900, how many have been developed and mined 100 years later?

Answer. A single number cannot be determined. It is fair to say that many coal beds considered unmineable 100 years ago are now being mined. We are mining deeper and thinner seams than 100 years ago, mainly through development of mining technology.

Question 3. Can you estimate what percent of our counties' coal resources will be considered unmineable 100 years from now?

Answer. Again, this is a very difficult question to answer because with technological developments, one might expect to mine coal beds in the future that are currently unmineable.

Question 4. If we do inject large quantities of carbon dioxide into these unmineable coal seams, how might that affect our ability to mine them in the future?

Answer. This is an important consideration when evaluating potential carbon sequestration sites in coal beds. Future technological advances may allow for the mining of coal resources that are presently deemed unmineable. Storing industrial carbon dioxide in presently unmineable coal beds may preclude future use of those coal resources.

There have been a number of questions and concerns about liability for storing carbon dioxide in long-term repositories.

Question 1. How will you assess the potential impact or risk of storing this carbon dioxide to other mineral deposits above or near these injection sites?

Answer. The potential exists for carbon dioxide storage, and the associated carbon dioxide injection infrastructure, to affect both surface and subsurface mineral resource deposits. The USGS Mineral Resources Program (MRP) data showing locations of known mineral deposits, together with MRP's published assessments of potential for undiscovered deposits, could be combined with evaluations of carbon dioxide storage potential to identify areas in which these risks need to be evaluated.

Question 2. How will you assess the potential impact of storing, and potential leakage of, this carbon dioxide into ground water and its impact on water rights above or near these injection sites?

Answer. Current design considerations for geologic carbon dioxide storage and sequestration stipulate the depth of storage to be 3000 feet or greater and the salinity of the water in the storage formation to be greater than 10,000 parts per million total dissolved solids (according to EPA's Underground Injection Control limit for injection of produced water from petroleum operations). The high salinity of water in these prospective storage formations means that they are not currently part of the potable ground water supply. However, future desalination technologies might allow for waters with salinities as high as seawater (35,000 parts per million total dissolved salts) to be made potable. Therefore, as much information as possible on each formation's depths, salt concentrations, etc., will be incorporated into the assessment. In addition, all formations that will be assessed for storage capacity will have identified sealing formations, commonly described as aquitards or aquicludes, which isolate the prospective storage formation from known and future supplies of potable water. These seals should prevent injected carbon dioxide or saline formation water in the storage formation from migrating to shallower levels and contaminating potable groundwater supplies. A critical component of any assessment would be evaluating the effectiveness and sealing capacity of seals and developing monitoring protocols for early detection of leaks.

Question 3. How will you assess the potential for this carbon dioxide to somehow lubricate known and unknown faults in or near the injection sites?

Answer. Activation (lubrication) of faults by carbon dioxide injection is a critical component of the evaluation of the storage capacity of any potential storage site with known faulting. If faults are a component of known oil and gas accumulations, we will use the properties of the petroleum accumulations to model the stresses necessary to activate the faults. Storage capacities would be calculated for volumes of carbon dioxide that will not exceed the activation potential of the known faults.

The role of "unknown" faults is difficult to evaluate. However, in assessment units with known faulting we will use geological models of faulting with geostatistical methods to estimate the size and distribution of unidentified faults. Knowledge of faulting would be critically dependent on the quality of subsurface information available to our assessment teams. In areas with publicly available, high resolution, 3-D seismic imaging, we will know much more about the distribution of faulting than in areas where we do not have access to seismic data or only have access to low resolution, 2-D seismic images.

Question 4. How will you estimate and discuss the potential damage from earthquakes that could be facilitated by the lubrication of faults in or near the injection sites?

Answer. Estimates of potential damage from earthquakes are beyond the scope of the proposed assessment activity. As noted in the discussion of potential activation of faults by carbon dioxide injection and storage, the estimates of storage volumes will be based on models of fault activation and the volumes and pressures during injection will be below the thresholds for fault activation. Fault activation is an important issue in the regulatory framework for underground fluid injection within the EPA Underground Injection Control (UIC) program. Current regulations in the UIC program require that pressures during injection are lower than the threshold for rock fracture and fault activation. Finally, USGS has considerable experience in evaluating and modeling the occurrence of earthquakes due to underground fluid injection. A large body of research was conducted in the early 1970's at the Rangely oil field in Colorado where earthquakes were caused by water injection. Based on that research current injection practice rarely induces minor earthquakes, and earthquake activity due to fluid injection, including carbon dioxide injection, at Rangely has not been a problem.

The Department of Energy (DOE) and the U.S. Geological Survey share responsibility for research related to site selection, monitoring, and verification of candidate carbon sequestration sites.

Question 1. Could each of you describe, in your own view, how the responsibilities should be divided between your agencies?

Answer. The USGS and DOE have complementary missions and goals. The USGS is focused on geologic research and characterization and resource assessment, whereas DOE is more focused on technological development and pilot tests. There are some areas of overlap between these two end members, and the whole spectrum is needed in order to understand complex issues such as carbon dioxide sequestration. Communication and coordination will be important to maximize effectiveness and avoid any duplication of effort.

Question 2. How can the Federal government work most effectively with the State geological surveys?

Answer. The USGS and DOE, as well as other organizations, have a long history of working with the State Geological Surveys. In particular, USGS works closely with the State Geological Surveys on a variety of issues. In the context of geologic carbon dioxide sequestration, the USGS will work most effectively with the State geological surveys by consulting these and other relevant entities during both the methodology review and assessment process. These interactions will serve to identify existing relevant datasets, as well as identify knowledge gaps, and build upon these existing data so as to maximize the usefulness and success of the assessment.

Responses of the Department of the Interior to Questions From Senator Salazar

Question 1. In your testimony, you indicated that one year would be sufficient to develop the peer-reviewed methodology called for in S. 731. What are the technical obstacles to coming up with a methodology in the time frame required in the bill? If you had more resources to hire or contract out help, would you be able to meet that deadline?

Answer. It will take some time to develop a methodology because all of the stakeholders must be brought together in order to understand what work has already been done, what data are available and suitable for an assessment, and to understand the rules and constraints facing regulatory organizations such as EPA, including issues of long-term viability and permanence of storage projects. Additional resources would not necessarily speed the process. A national assessment must be useable to a variety of organizations, stakeholders, and policy makers. Further, criteria for defining and ranking storage sites must be developed, the definition of an assessment unit and the total carbon storage system within basins and regions needs to be developed, the definition of risk factors must be developed, and major data gaps need to be identified. We must review and incorporate in the methodology the performance of existing projects that inject carbon dioxide into oil fields for enhanced oil recovery, such as the Rangely field, Colorado. In addition, an evaluation of current sequestration pilot projects, such as the Frio Brine, Houston, Texas; Sleipner, Norway; Weyburn, Canada; and In-Salah, Algeria, must be undertaken in order to understand the amount of carbon dioxide they have been able to sequester, whether that carbon dioxide stayed sequestered or moved during the project, and other geological and technical obstacles or successes. A critical issue in developing a methodology will be identification of geological criteria necessary to evaluate the longterm integrity of sequestration sites.

Question 2. What has the USGS done so far to assess sequestration capacity? What have USGS scientists published on this topic? Could the existing and pub-

lished assessment methodologies serve as a basis for an initial methodology to be reviewed? Could that methodology be expanded upon?

Answer. The USGS has conducted research in characterizing oil and gas reservoirs, coal beds, and saline water bearing formations in the context of geologic carbon dioxide sequestration. These USGS research activities provide information and understanding of how carbon dioxide will behave in these settings (the physical and chemical interactions between geologic formations and carbon dioxide). This information has been used to develop preliminary concepts for use in sequestration capacity assessments, including the environmental effects associated with geologic carbon dioxide sequestration.

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USGS scientists have published a number of peer-reviewed papers and reports pertaining to geologic carbon dioxide sequestration in geologic formations. A partial list of these existing products, with the primary focus theme, includes:

(a) oil and gas reservoir characterization for geologic carbon dioxide sequestration:

- S.T. Brennan, K.O. Dennen, and R.C. Burruss. 2006. Timing of hydrocarbon emplacement in ozokerite and calcite lined fractures, Teapot Dome, Wyoming. U.S. Geological Survey Open File Report 2006-1214, 28 p. Available at: http://erg.usgs.gov/isb/pubs/ofrs/2006-1214/0FR2006-1214.pdf
- S.T. Brennan, V.A. Hughes, S.J. Friedmann, and R.C. Burruss. 2005. NATURAL GAS RESERVOIRS WITH HIGH CO_2 CONCENTRATIONS AS NATURAL ANALOGS FOR CO_2 STORAGE. In M. Wilson, T. Morris, J. Gale, and K. Thambimuthu (eds.), Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies, 5-9 September 2004, Vancouver, Canada, Volume II, p. 1381-1387.

(b) coal bed characterization for geologic carbon dioxide sequestration:

- J.J. Kolak and R.C. Burruss. 2006. Geochemical Investigation of the Potential for Mobilizing Non-Methane Hydrocarbons during Carbon Dioxide Storage in Deep Coal Beds. Energy & Fuels 2006, 20, 566-574.
- J.J. Kolak and R.C. Burruss. 2005. The Effect of Coal Rank on the Physicochemical Interactions Between Coal and CO_2—Implications for CO_2 Storage in Coal Beds. In M. Wilson, T. Morris, J. Gale, and K. Thambimuthu (eds.), Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies, 5-9 September 2004, Vancouver, Canada, Volume II, p. 2233-2237.

(c) saline water bearing formations characterization for geologic carbon dioxide sequestration:

- Y.K. Kharaka, D.R. Cole, S.D. Hovorka, W.D. Gunter, K.G. Knauss, B.M. Freifeld. 2006. Gas-water-rock interactions in Frio Formation following CO_2 injection: Implications for the storage of greenhouse gases in sedimentary basins. Geology, v. 34; no. 7; p. 577-580.

(d) concepts for geologic carbon dioxide storage capacity assessments:

- S. T. Brennan and R.C. Burruss. 2006. Specific Storage Volumes: A Useful Tool for CO_2 Storage Capacity Assessment. Natural Resources Research, Vol. 15, No. 3, P. 165-182.
- R.C. Burruss. 2004. Geologic Sequestration of Carbon Dioxide in the Next 10 to 50 Years: An Energy Resource Perspective. In Workshop Proceedings, The 10-50 Solution: Technologies and Policies for a Low-Carbon Future, Pew Center on Global Climate Change, March 25-26, 2004, Washington, D.C., 7p.
- R.C. Burruss and S.T. Brennan. 2003. Geologic Sequestration of Carbon Dioxide—An Energy Resource Perspective. U.S. Geological Survey Fact Sheet 026-03, 2p. Available at: http://pubs.usgs.gov/fs/fs026-03/
- M.K. Verma. 2005, Role of Rock/Fluid Characteristics in Carbon (CO_2) Storage and Modeling: U.S. Geological Survey Open-File Report 2005-1137, 27 p. http://pubs.usgs.gov/of/2005/1137/
- James L. Palandri, Yousif K. Kharaka. 2005. Ferric iron-bearing sediments as a mineral trap for CO_2 sequestration: Iron reduction using sulfur-bearing waste gas. Chemical Geology 217 (2005) 351-364

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The USGS research published to date provides an objective, scientifically robust, peer-reviewed knowledge base that can be used as a basis to develop an initial methodology for review. Such a methodology would expand on the published USGS storage capacity concepts. In our view, it is essential to develop a sound assessment

methodology, which would involve a strong peer-review and external vetting process of that methodology. These steps are necessary before commencing a national assessment of carbon dioxide storage capacity in geologic formations to ensure that the information resulting from the assessment is most useful for future decision making about sequestration efforts.

Question 3. What data bases (such as for oil and gas or coal) does USGS now have in place that could apply to an assessment of sequestration capacity in the U.S.?

Answer. The USGS has several databases—available to the public through the internet—that could be applied to a national storage capacity assessment of carbon dioxide in geologic formations. These databases include the USGS Organic Geochemistry Database (http://energy.cr.usgs.gov/prov/og/), the USGS National Coal Resources Data System (http://energy.er.usgs.govicoal—quality/coal—databases.html), and the USGS Produced Waters Database (http://energy.cr.usgs.gov/prov/prodwat/). The USGS also has available to the public through the internet an extensive array of geographic information system layers pertaining to oil and gas and coal resources that can be applied to such an assessment.

NATURAL RESOURCES DEFENSE COUNCIL,
Washington, DC, May 7, 2007.

Hon. JEFF BINGAMAN,
Chairman, Committee on Energy and Natural Resources, U.S. Senate, Dirksen Senate Building, Washington, DC.

DEAR CHAIRMAN BINGAMAN: Per your request, enclosed please find my responses to your questions from the full committee hearing on carbon sequestration on April 16, 2007, which will be included in the hearing record.

Sincerely,

DAVID G. HAWKINS,
Director, Climate Center.

[Enclosure.]

QUESTION FROM SENATOR BINGAMAN

Question. As Mr. Coddington addressed in his testimony, will the recent US Supreme Court ruling that the EPA has the authority, under the Clean Air Act, to enact limits on carbon dioxide (CO_2) emissions (as an air pollutant) carry over to injection of carbon dioxide into geologic storage sites? Will the treatment of CO_2 as a waste pollutant versus a commodity that can that can be used for enhanced oil recovery or other uses pose a significant hindrance to rapid deployment of large-scale demonstration projects?

Answer. We do not believe so. Injection of CO_2 is currently governed by the Underground Injection Control Program (UIC), which derives from the Safe Drinking Water Act (SDWA). CO_2 has been an allowed injectant for many years now. The primary focus of the UIC is to protect groundwater, whereas the Supreme Court decision relates CO_2's disruption of the climate through the so-called greenhouse effect Under the Clean Air Act, CO_2 injection projects can and should be subject to performance standards and/or operational requirements to prevent leakage of CO_2 back to the atmosphere. Such requirements are practical and should not interfere with rapid deployment of large-scale injection projects.

QUESTION FROM SENATOR DOMENICI

Question. You stated in your testimony that these resources are just as important as oil and gas and that we should therefore go forward with geopolitical mapping so that we can inventory our Nation's assets with respect to storing carbon dioxide. Using your comparison, do you similarly support an oil and gas inventory of the Outer Continental Shelf?

Answer. We do not support an oil and gas inventory of the Outer Continental Shelf (OCS). The two inventories serve very different purposes: the OCS inventory is clearly part of an effort to overturn sound congressional policy—the moratorium on drilling in those parts of the OCS not now being exploited. Offshore drilling comes with several environmental pitfalls: damage to sensitive coastal ecosystems from infrastructure siting, danger of oil spills, water pollution from waste muds, cuttings and produced water, as well as air pollution. Additionally, the oil/gas inventory will involve offshore seismic exploration, which has major impacts on marine mammals and fish. There are far better and cleaner ways to meet our energy demand through efficiency improvements or even incremental oil produced onshore through enhanced recovery with permanent CO_2 sequestration.

In contrast, the survey of potential CO_2 repositories is a broad initial survey that does not pose risks to health or the environment. The CO_2 repository assessment will primarily be based on existing information, complemented by drilling sampling wells. We do not expect seismic methods would be used, as these provide information on the geometry and spatial distribution of formations. Well logs, cores and fluid samples obtained from the wells are the methods that will reveal porosity, injectivity and composition, needed to deduce CO_2 storage capacity.

RESPONSES OF MR. CODDINGTON TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. In Mr. Hawkins testimony, he states the there are areas around the US that were not assessed, while other testimony provided states that those areas in the US where data is not available represents areas where geological storage potential is slim. Would it be helpful to obtain field confirmation, in the form of drill wells and well data, to determine whether formations are suitable for carbon dioxide storage in those areas?

Answer. The question assumes that geologic storage will be widely deployed in all regions of the country at a date certain—and perhaps in the near future. Under that scenario, it is certainly true that all potentially desirable geologic data, particularly with respect to deep saline formations, are not available in all regions of the country. If that deployment scenario is accurate, then I concur that it would be helpful to obtain field confirmation, in the form of drill wells and well data, to determine whether formations are suitable for carbon dioxide storage in areas of the country where geologic data may be less robust.

It is possible, however, that the deployment scenario underlying the question may turn out to be invalid. I believe that it is possible that geologic storage may be deployed initially in those parts of the country in which the geology is already well understood and characterized. Those formations necessarily include, but are not limited to, oil & gas reservoirs. Injection into those formations constitutes storage, in my view, so must be part of the discussion. Data on such formations generally are robust, although on a case-by-case basis—and likely as part of the site assessment for a major commercial project in any event—additional reservoir characterization data may be required.

Thus, while I believe that it always helpful to have more data, particularly with respect to deep saline formations, the development of a geologic storage industry in the United States does not necessarily have to wait on the development of a national database of all conceivable geologic storage formations.

Question 2. After hearing all of today's testimony, it is important to consider how the liability surrounding large-scale CO_2 injection will impact the deployment of the projects we've been discussing. Would the liabilities that were discussed today be better handled at the Federal or State level? The testimony today sends a bit of a mixed message as to which level is better suited to employ liability management.

Answer. I believe that the analysis has not been done to answer the question of whether liabilities are better addressed at the Federal or State level. Various policy models are available, however, and each should be examined to determine which best meets the needs of the public, the environment, and private industry.

My sense is that private industry, as part of the project evaluation process, wants to know that liabilities are being addressed in a responsible and fiscally sound manner. Thus, if the governmental policy goal is to spur commercial CCS projects, the manner in which liabilities are addressed may be more important than the level of government—State of Federal—which would be acting. A well-conceived and financed State liability scheme, for example, may provide more of an incentive for large scale commercial CCS projects than a well-conceived but nonetheless poorly funded Federal program (or vice versa).

RESPONSE OF MR. CODDINGTON TO QUESTION FROM SENATOR DOMENICI

Question 1. In your testimony you discuss the great uncertainty associated with long-term liability for geologic carbon storage. Do you believe this uncertainty is discouraging private industry from investing in carbon capture and storage technologies?.

Answer. I believe that uncertainties regarding liabilities for geologic storage—particularly those associated with long-term storage.

Liability of the storage sites is most definitely a function of the geologic nature of the reservoirs and overlying sediments. Certain subsurface conditions, such as those in SE New Mexico and West Texas are ideally suited for large-scale injection. Liability there is effectively zero. Liability in fractured granite or basalt, on the other hand, is a huge issue and fraught with questions of permanence of storage.

Curiously perhaps, the sites with the least risk are the sites we know most about, the oil and gas provinces. We need to tell and retell that story.

Initial projects need to be located in those regions with thick sedimentary rock sequences; ones very much like the regions within which we have explored for oil and gas. This will produce success and occur in regions where the public is used to drilling and injection activity. We can begin to branch out from there to areas currently perceived with higher liability. The oil and gas companies know those initial regions and know the injection technologies that have been proven to work for decades. We must include that industry and their regulators in the CCS development to minimize those risks and liabilities.

RESPONSES OF DR. GUTHRIE TO QUESTIONS FROM SENATOR BINGAMAN

Question 1. In Mr. Hawkins testimony, he states the there are areas around the US that were not assessed, while other testimony provided states that those areas in the US where data is not available represents areas where geological storage potential is slim. Would it be helpful to obtain field confirmation, in the form of drill wells and well data, to determine whether formations are suitable for carbon dioxide storage in those areas?

Answer. Initial capacity estimates are covering the most promising regions with respect to storage potential. They are based largely on existing data and a number of assumptions, so most of the estimates have relatively large error bars.

Through the efforts of the Regional Partnerships, we are building our understanding of the national capacity that is likely to exist. Not all portions of the U.S. are being covered, nor within the studied regions are all sites being assessed at the same level of detail. This reflects a prioritization by the Partnerships given the limited scope of the efforts—due to limitations in resources, time, and data (particularly on deep saline formations that have not been explored for other reasons).

A more comprehensive effort could improve our estimates of both national and regional capacities, and this will certainly be needed to understand the long-term role of geologic storage in the energy portfolio.

Nevertheless, current estimates support the conclusion that sufficient capacity is likely to exist for at least decades of large-scale injection (i.e., insufficient information on capacity is not a major impediment to a decision to move forward on field studies).

Ultimately, accurate capacity estimates will require very detailed field investigations, not only involving data from wells (to assess parameters like porosity, permeability, and injectivity) but also detailed geological and geophysical studies (to assess reservoir parameters such as heterogeneity, reservoir geometry, and potential release pathways).

Question 2. After hearing all of today's testimony, it is important to consider how the liability surrounding large-scale CO_2 injection will impact the deployment of the projects we've been discussing. Would the liabilities that were discussed today be better handled at the Federal or State level? The testimony today sends a bit of a mixed message as to which level is better suited to employ liability management.

Answer. From a technical perspective, there is no significant reason to choose one level of government over another for handling liability issues, albeit geologic reservoirs can cross state boundaries. From a business perspective, I would imagine that a common approach to these issues throughout the U.S. would facilitate making decisions based on relative technical merits of candidate sites. In this context, having a common approach to assessing sites will be important. For example, a common risk assessment framework and methodology would enable inter-comparison of sites on a technical basis. However, even given a common approach, there will be need to accommodate variability in regional specifics that impact liability.

Question 3. As Mr. Coddington addressed in his testimony, will the recent US Supreme Court ruling that the EPA has the authority, under the Clean Air Act, to enact limits on carbon dioxide (CO_2) emissions (as an air pollutant) carry over to injection of carbon dioxide into geologic storage sites? Will the treatment of CO_2 as a waste pollutant versus a commodity that can be used for enhanced oil recovery or other uses pose a significant hindrance to rapid deployment of large-scale demonstration projects?

Answer. From a technical perspective, there is no reason to argue that CO_2 in the atmosphere or subsurface should be classified differently or similarly. From a technical perspective, the primary distinction between injecting CO_2 for enhanced oil recovery versus for geologic storage is the need to address the long-term nature of storage. These include understanding the long-term fate of CO_2 and its potential im-

pact on the engineered and geologic systems and the need to verify the effectiveness of storage using monitoring methodologies.

RESPONSE OF DR. GUTHRIE TO QUESTION FROM SENATOR DOMENICI

Question 1. When people talk about carbon sequestration, there's a lot of discussion about where to inject CO_2 to start gathering data to see if this is workable on the large scale. Dr. Guthrie, from a technical standpoint, can you tell me where we should be focusing as a country? Should we focus on green-field sites, enhanced oil recovery sites? Give me your thoughts.

Answer. Both types of sites (green-field and brown-field) can provide unique information needed to improve our understanding of geologic storage as a feasible option.

Brown-field sites have an existing infrastructure and economic drivers, which facilitates deployment. Green-field sites are closer to some of the large point sources of CO_2, and they expand our experience base with respect to variations in geological environments, which will be critical for large scale deployment.

An additional type of field study is also required to improve our understanding of the long-term aspects of geological storage. Specifically, analog sites—where significant volumes of CO_2 were introduced in the past, either by natural process or as part of an engineered operation like enhanced oil recovery—provide information on the long-term factors in geological storage. This type of information cannot be obtained from newly started CO_2 injection efforts.

RESPONSE OF MR. HAWKINS TO QUESTION FROM SENATOR BINGAMAN

Question. As Mr. Coddington addressed in his testimony, will the recent US Supreme Court ruling that the EPA has the authority, under the Clean Air Act, to enact limits on carbon dioxide (CO_2) emissions (as an air pollutant) carry over to injection of carbon dioxide into geologic storage sites? Will the treatment of CO_2 as a waste pollutant versus a commodity that can that can be used for enhanced oil recovery or other uses pose a significant hindrance to rapid deployment of large-scale demonstration projects?

Answer. We do not believe so. Injection of CO_2 is currently governed by the Underground Injection Control Program (UIC), which derives from the Safe Drinking Water Act (SDWA). CO_2 has been an allowed injectant for many years now. The primary focus of the UIC is to protect groundwater, whereas the Supreme Court decision relates CO_2's disruption of the climate through the so-called greenhouse effect. Under the Clean Air Act, CO_2 injection projects can and should be subject to performance standards and/or operational requirements to prevent leakage of CO_2 back to the atmosphere. Such requirements are practical and should not interfere with rapid deployment of large-scale injection projects.

RESPONSE OF MR. HAWKINS TO QUESTION FROM SENATOR DOMENICI

Question. You stated in your testimony that these resources are just as important as oil and gas and that we should therefore go forward with geopolitical mapping so that we can inventory our Nation's assets with respect to storing carbon dioxide. Using your comparison, do you similarly support an oil and gas inventory of the Outer Continental Shelf?

Answer. We do not support an oil and gas inventory of the Outer Continental Shelf (OCS). The two inventories serve very different purposes: the OCS inventory is clearly part of an effort to overturn sound congressional policy—the moratorium on drilling in those parts of the OCS not now being exploited. Offshore drilling comes with several environmental pitfalls: damage to sensitive coastal ecosystems from infrastructure siting, danger of oil spills, water pollution from waste muds, cuttings and produced water, as well as air pollution. Additionally, the oil/gas inventory will involve offshore seismic exploration, which has major impacts on marine mammals and fish. There are far better and cleaner ways to meet our energy demand through efficiency improvements or even incremental oil produced onshore through enhanced recovery with permanent CO_2 sequestration.

In contrast, the survey of potential CO_2 repositories is a broad initial survey that does not pose risks to health or the environment. The CO_2 repository assessment will primarily be based on existing information, complemented by drilling sampling wells. We do not expect seismic methods would be used, as these provide information on the geometry and spatial distribution of formations. Well logs, cores and fluid samples obtained from the wells are the methods that will reveal porosity, injectivity and composition, needed to deduce CO_2 storage capacity.

APPENDIX II

Additional Material Submitted for the Record

NATIONAL ENVIRONMENTAL TRUST,
Washington, DC, March 8, 2007.

Hon. KEN SALAZAR,
U.S. Senate, Hart Senate Office Building, Washington, DC.

DEAR SENATOR: Thank you for your leadership on carbon sequestration and for the introduction of S. 731, the National Carbon Dioxide Storage Capacity Assessment Act of 2007.

We are pleased to support this legislation, which directs the U.S. Geological Survey to conduct a comprehensive assessment of geological storage capacity for carbon dioxide in all 50 states.

It is vital for Congress to ensure that the United States identifies and uses the energy sources that are compatible with a policy to limit global warming. We consider aggressive promotion of energy conservation and renewable energy to be the best first choices in meeting new energy needs, but also understand that coal is likely to continue to be an important source of energy.

Carbon capture and sequestration (CCS) is frequently heralded as the technology solution that will allow the United States to rely on coal in a carbon-constrained world. However, it is vital that we establish with certainty that we can safely and securely manage the carbon dioxide emissions resulting from coal use.

The "Future of Coal" study recently released by the Massachusetts Institute of Technology outlines a clear path forward to develop the knowledge base and regulations necessary to ensure what we need to manage the emissions from future coal use. The study stresses that while CCS may be the "critical enabling technology" that makes continued reliance on coal viable, "the priority objective with respect to coal should be the successful large-scale demonstration of the technical economic and environmental performance of the technologies that make up all of the major components of a large-scale integrated CCS system—capture, transportation and storage."

Your bill is a good first step to making sure that coal emissions can be sequestered without causing additional risks to public health, the climate and the environment.

Meeting the challenge of global warming will require forward thinking and innovation as well as practical solutions. Your demonstration of leadership to advance research and fact finding on this potential technology is commendable.

Sincerely,

ANGELA LEDFORD ANDERSON,
Vice President, Climate Programs.

AMERICAN PUBLIC POWER ASSOCIATION,
Washington, DC, April 3, 2007.

Hon. KEN SALAZAR,
Hart Senate Office Building, Washington, DC.

DEAR SENATOR SALAZAR: I am writing to express the American Public Power Association's (APPA) support for your bill (S. 731) designed to develop a methodology for, and complete a national assessment of, geological storage capacity for carbon dioxide.

APPA is the national service organization representing the interests of the over 2,000 state and locally owned electric utilities nationwide that collectively serve over 44 million Americans. Given their nature as community-owned utilities, governed at the local level, and directly accountable to the citizens they serve, public power sys-

tems continue to demonstrate a high degree of commitment to environmental stewardship and to addressing environmental concerns.

As you know, the emissions of greenhouse gases primarily from the combustion of fossil fuels, and the linkage of those emissions to global climate change is the most significant environmental policy issue confronting the nation today. In addition, discussion, debate, and concern within the scientific community as well as with the general public regarding the effects of these emissions on the physical environment and the economic consequences of programs to reduce these emissions is prompting action by federal, state and local policymakers.

As Congress continues to debate climate change, one of the most frequently discussed technologies is that of carbon capture and storage. While this may be a viable option to address climate change, there are major challenges that must be overcome, both technically and in public policy, before widespread commercial-scale carbon capture and storage can be achieved. APPA believes your bill is a step in the right direction to overcoming these challenges.

Again, thank you for your dedication and hard work on this matter and we look forward to working with you as your legislation moves forward.

Sincerely,

ALAN H. RICHARDSON,
President & CEO.

COLORADO ASSOCIATION OF MUNICIPAL UTILITIES,
Ft. Colins, CO, April 5, 2007.

Hon. KEN SALAZAR,
Hart Senate Office Building, Washington, DC.

DEAR SENATOR SALAZAR: It was a pleasure to meet with you and Steve Black last month in Washington, D.C. I know the mayors especially appreciate you taking the time to meet with them to discuss various issues important in their communities. They are among a handful of the 29 municipally owned electric utilities CAMU represents—utilities that provide electric service to 20% of Colorado's population.

During our meeting, we discussed your bill, S. 731. The bill is designed to develop a methodology for, and complete a national assessment of, geological storage capacity for carbon dioxide using the services of the U.S. Geological Survey. CAW supports your bill as an important step toward understanding how CO_2 emissions can be captured and sequestered in a safe and environmentally sound way.

Our state of Colorado faces a big challenge. The Colorado Energy Forum last year determined the state's electric utilities collectively have to build an additional 5,000 megawatts of generation capacity by 2020 to "keep the lights on." Currently, coal provides 75% of the electricity Coloradans use. Coal and natural gas very likely will be fuel sources used by this new generation. It's imperative that these important fuels continue to be in the state's generation mix. However, growing concern about greenhouse gas contributions to climate change necessitates that new technologies be developed that remove CO_2 from fossil fuel emissions from the atmosphere. Capturing and sequestering CO_2 is a process and technology that generates much interest and shows much promise. However, important technical questions and public policy issues need to be answered before widespread commercial-scale carbon capture and storage can be achieved. CAMU believes your bill is an important step in the right direction to providing answers to these questions.

We look forward to our continued work with you and Steve on this and the many other important issues facing the energy industry.

Sincerely,

DAVID LOCK,
Executive Director.

PLATTE RIVER POWER AUTHORITY,
Ft. Colins, CO, April 11, 2007.

Hon. KEN SALAZAR,
Hart Senate Office Building, Washington, DC.

DEAR SENATOR SALAZAR: I write to convey Platte River Power Authority's support of S. 731.

Platte River is the joint action agency that provides wholesale electric and transmission service to the municipal utilities of Fort Collins, Longmont, Loveland and Estes Park. Platte River is proud of its environmental record and has demonstrated our willingness to control emissions from our power plants as soon as technology

becomes available. Our Rawhide Energy Station will be one of the first plants in Colorado to install equipment to control mercury emissions in 2009. Rawhide has consistently been the "cleanest" coal-fired electric plant in Colorado and one of the cleanest in the U.S., thanks to the equipment we installed to control sulfur-dioxide and nitrogen-oxide.

Platte River and our country now face our biggest environmental challenge—how to reduce carbon-dioxide emissions from fossil fueled generation plants and other sources of CO_2. Your bill, S. 731, is an important step toward achieving that goal. The bill is designed to develop a methodology for, and complete a national assessment of, geological storage capacity for carbon dioxide using the services of the U.S. Geological Survey. Capturing and sequestering CO_2 is a process and technology that shows much promise. However, major questions need to be answered, both technically and in public policy, before widespread commercial-scale carbon capture and storage can be achieved. Platte River believes your bill is an important step in the right direction to providing answers to these questions.

We applaud your leadership in this area and look forward to working with you on this issue and the many others facing our industry.

Sincerely,

BRIAN MOECK,
General Manager.

COLORADO SPRINGS UTILITIES,
Colorado Springs, CO, April 11, 2007.

DEAR SENATOR SALAZAR: Colorado Springs Utilities is pleased to write you to offer our support for the S. 731, The National Carbon Dioxide Storage Capacity Assessment Act of 2007. As you know, Colorado Springs Utilities is the largest municipal utility in Colorado, supplying retail electric service to Colorado Springs and Manitou Springs, as well as contract power sales to the United States Air Force Academy, Peterson Air Force Base and Fort Carson.

To meet the ever growing energy demands of the Pikes Peak region in an affordable and efficient manner, Colorado Springs Utilities generates almost 70% of its electricity from coal fired power plants. Because coal is both a cheap and abundant fuel source in the inter-mountain West, energy derived from coal will continue to play a large and indispensable role in Colorado Springs generating portfolio into the foreseeable future.

We fully realize that constraints on carbon emissions in the United States may be imminent, and recognize that we must start thinking now about how to operate our power plants in a carbon constrained world. These realities make our mission of protecting our rate payers from excessive price increases very difficult, but we are committed to working with you and the rest of Congress to craft policies that balance both the need to address carbon emissions with the economic well being of our community.

We applaud the National Carbon Dioxide Storage Capacity Assessment Act of 2007 as an important first step toward managing carbon emissions. By calling on the United States Geological Service (USGS) to conduct a comprehensive inventory of the Nation's ability to store carbon in appropriate geologic features and other natural basins, starting with the requirement for USGS to develop an official methodology for the assessment, we are convinced that your bill will go a long way toward closing the knowledge gaps that surround carbon storage in the United States.

Thank you for striving to help secure America's energy needs through coal, while thinking proactively about how to effectively and affordably manage carbon emissions. We appreciate the bipartisan bill you have introduced, and fully stand behind it.

Sincerely,

TOM BLACK,
Energy Services Officer.

ENVIRONMENTAL DEFENSE,
New York, NY, April 12, 2007.

Hon. KEN SALAZAR,
U.S. Senate, Hart Senate Office Building, Washington, DC.

Re: National Carbon Dioxide Storage Capacity Assessment Act of 2007

DEAR SENATOR SALAZAR: I am writing to express Environmental Defense's support for the National. Carbon Dioxide Storage Capacity Assessment Act of 2007. Your

legislation recognizes that, even while the Congress designs an economy-wide cap for US greenhouse gases, we can make progress on the technology and infrastructure that enables such a cap.

The recent MIT report *The Future of Coal* makes clear how important carbon capture and storage technology is. Your legislation helps advance that technology by determining the location and storage potential of geologic formations in the US.

Thank you again for introducing legislation that helps address the greatest environmental challenge that Americans face today. I look forward to working with you on the National Carbon Dioxide Storage Capacity Assessment Act and on climate change legislation as both move forward in the Congress.

Yours truly,

FRED KRUPP,
President.

XCEL ENERGY,
Minneapolis, MN, April 16, 2007.

Hon. KEN SALAZAR,
U.S. Senator, Hart Senate Office Building, Washington, DC.

Re: S. 731

DEAR SENATOR SALAZAR: I am writing to express Xcel Energy's strong support for S. 731.

Xcel Energy is the nation's fifth largest combined electric and gas utility, serving 3.3 million electric customers and 1.8 million gas customers in eight states, including Colorado, Minnesota, Wisconsin, Texas, North and South Dakota, Michigan and New Mexico. The company is the No. 1 wind provider in the nation and is rapidly expanding its support for solar energy. We are also a member of the Dow Jones sustainability index and have undertaken many innovative environmental initiatives, including voluntary emission reduction, renewable energy and advanced technology programs.

I have committed Xcel Energy to meet our customers' energy needs in a reliable, cost-effective and environmentally responsible manner. At a time when Congress is considering a number of proposals to address climate change and the emissions of greenhouse gases, we have already begun to explore new technologies that will enable us to fulfill these commitments to our customers in a clean energy future. Xcel Energy is at this moment engaged in studying the feasibility of developing an integrated gasification combined cycle (IGCC) facility in Colorado. If approved, the facility would be the first of its kind to capture and sequester carbon dioxide emissions. I believe this technology holds great promise to allow continued use of American coal to generate electricity while substantially reducing emissions of greenhouse gases.

The challenges of carbon sequestration, however, are real. S. 731 will help our company and the industry meet those challenges by identifying the scope of the nation's geologic sequestration resources in greater detail. It is a crucial step in the deployment of clean coal technologies. For this reason, I strongly support S. 731 and urge its passage.

Very truly yours,

RICHARD C. KELLY,
Chairman, President and CEO.

NATIONAL MINING ASSOCIATION,
Washington, DC, April 17, 2007.

Hon. JEFF BINGAMAN,
Chairman, Committee on Energy and Natural Resources, U.S. Senate, Washington, DC.

DEAR CHAIRMAN BINGAMAN: The National Mining Association (NMA) wishes to convey its strong support for the Department of Energy Carbon Capture and Storage Research, Development and Demonstration Act (S. 962) sponsored by you and Senator Domenici, and the National Carbon Dioxide Storage Capacity Assessment Act of 2007 (S. 731) sponsored by Senators Salazar and Bunning.

NMA extends its thanks to you and the members of the Committee on Energy and Natural Resources for your bi-partisan leadership in introducing this important legislation. S. 962 will triple funding levels recently provided for carbon capture and storage (CCS) efforts, expediting a much-needed, large-scale testing of this highly promising technology. S. 731 is a constructive and much-needed initiative that will

compliment efforts to develop CCS technology by providing information that America will need to safely store carbon dioxide.

As experts from a variety of disciplines have testified in past weeks at congressional hearings, coal use in the U.S. and worldwide will increase under any foreseeable scenario because of its abundance, accessibility, affordability and contribution to energy security. CCS technologies offer a safe and economically viable approach to meeting the country's energy and environmental needs in the years ahead.

Sincerely yours,

KRAIG R. NAASZ,
President & CEO.

STATEMENT OF ROBERT J. FINLEY, DIRECTOR, ENERGY AND EARTH RESOURCES CENTER, ILLINOIS STATE GEOLOGICAL SURVEY

S. 731 addresses the important need for the U.S. to assess the national capacity for geological sequestration of carbon dioxide as a strategy to mitigate global climate change. As such, it is a critical step toward defining where we can safely and effectively store carbon dioxide (CO_2) in its various forms. The emphasis on well-defined methodology is entirely appropriate, and the comprehensive review provisions of this bill are certain to be supported by the scientific community dealing with sequestration issues. Yet, this bill can be further improved by reference to research that has already taken place within that community and that specifically addresses the methodology for carbon sequestration capacity assessment.

In July 2006, U.S. Department of Energy (DOE) managers for the Regional Carbon Sequestration Partnerships convened a meeting at the Kansas Geological Survey to begin the process of developing a Carbon Sequestration Atlas of the United States and Canada. This Atlas was released in digital form in March 2007 and the printed version will be available in May 2007. The Atlas documented some 3,500 billion tons of storage capacity in the regions covered by the Partnerships. It was developed on the basis of regional partnership work that had begun in 2003, and earlier, to understand the major geological reservoirs that may be utilized for carbon sequestration. This Atlas also builds on the work supported by DOE in the form of the original MIDCARB and now NATCARB digital databases accessible on the Internet. Methodology questions came up early in the preparation of this atlas and the current release contains careful documentation of the methodology adopted by a group of researchers from around the Nation with expertise in geology, reservoir engineering, and resource assessment. S. 731 would be significantly strengthened by referencing the DOE work, including the methodology documentation, as a starting point to avoid the obvious potential for duplication of the effort already expended. Clearly, a part of what is envisioned under S. 731 has been accomplished, and I would urge the Committee to reference the Atlas work in this legislation. Collaboration by the U.S. Geological Survey with the participants in the Regional Partnerships should be required. Other work, especially work on assessing incremental hydrocarbon recovery in a number of U.S. geologic basins using CO_2, has also been accomplished and should be referenced in Sec. 3(b)(4).

I was pleased to see the reference in Sec. 3(c)(2) to state coordination with geological surveys. State geological surveys and state oil and gas regulatory bodies have been essential sources of information for sequestration studies to date and will continue to be such for any new effort under S. 731. To that end, state geological surveys and state oil and gas regulatory bodies should also be specifically cited in Sec. 3(d) with respect to the opportunity to review and comment on the proposed methodology for the assessment. Without their input the potential for this assessment to be duplicative of previous work is even greater.

Finally, some words of caution are in order. The bill makes reference to injectivity of potential storage formations. This parameter is often difficult to quantify without site-specific testing. Likewise, risk associated with a storage formation may be volume dependent and/or injection rate dependent. The assessment of these parameters, to the extent we can know them in the near term, will be exceedingly difficult without collaboration with the Regional Carbon Sequestration Partnerships and the work these groups have done to date and will do in the coming months. Yet, this bill makes no reference to this program with respect to critical parameters, as it makes no reference to the work the Partnerships have done on capacity assessment to date. This leads me to again recommend that language be added requiring coordination with the Partnerships to deliver the most cost-effective product possible for the funding authorized to be invested in this effort.

AMERICAN PUBLIC POWER ASSOCIATION,
Washington, DC, April 18, 2007.

Hon. JEFF BINGAMAN,
Chairman, Senate Energy and Natural Resources Committee, Hart Senate Office Building, Washington, DC.

DEAR CHAIRMAN BINGAMAN: I am writing to express the American Public Power Association's (APPA) support for your bill (S. 962) that would amend the Energy Policy Act of 2005 to reauthorize and improve the carbon capture and storage research, development, and demonstration program of the Department of Energy.

As Congress continues to debate climate change, one of the most frequently discussed technologies is that of carbon capture and storage. While this may be a viable option to address climate change, there are major challenges that must be overcome, both technically and in public policy, before widespread commercial-scale carbon capture and storage can be achieved. APPA believes your bill is a step in the right direction to overcoming these challenges.

Again, thank you for your dedication and hard work on this matter and we look forward to working with you as your legislation moves forward.

Sincerely,

ALAN H. RICHARDSON,
President & CEO.

STATEMENT OF ROBERT J. FINLEY, DIRECTOR, ENERGY AND EARTH RESOURCES CENTER, ILLINOIS STATE GEOLOGICAL SURVEY

S. 962 meets important needs of the Nation with respect to furthering our understanding of carbon capture and sequestration (CCS) to mitigate impacts of carbon dioxide (CO_2) build-up in the atmosphere. Addressing CCS is essential if we are to have a full array of tools to begin addressing the emission reductions we need to make in a carbon managed future. I support the direction of this bill as it addresses the scope and funding necessary to meet these objectives. My purpose in offering these comments is to provide some additional perspective that I hope will be valuable in making this bill even more effective in achieving safe and effective deployment of carbon capture and sequestration. I offer these comments as a professional geologist and as principal investigator of one of the Department of Energy's (DOE) Regional Carbon Sequestration Partnerships.

I would begin by commending the recognition of the Regional Carbon Sequestration Partnerships expressed in Sec. 2(c)(2)(A). The Partnerships, awarded competitively in 2003 and again in 2005 by DOE, have provided much of the regionally specific information that is now being utilized by industry. I receive several inquiries per month from utilities, independent power producers, organizations developing coal-to-natural-gas and coal-to-liquids facilities, and environmental groups, all seeking understanding of CCS. The most relevant answers to their questions have come from our regional partnership research. For us in Illinois, the results of Partnership research were also very applicable in the effort to define sequestration opportunities for the two finalist FutureGen sites in Illinois, as I am sure results of the partnership program were also applicable in Texas. The reservoir targets in this section of S. 962 are indeed the major geologic targets for CO_2 storage; however, I am compelled to question any link between CO_2 storage and extraction of heat from geothermal systems. This is especially so since systems of "low permeability or porosity", as specified in the bill, are the opposite of the reservoir characteristics required for the volumes of CO_2 that must be dealt with in a carbon-managed environment.

Let me now turn to some very important provisions of S. 962 in Sec. 2 (C)(3-5) on pages six and seven. The provision for not less than seven large-volume tests is significant. The diversity of geological formations that underlies different regions of the U.S. requires that we gain knowledge and sequestration experience in the different types of rock units, rock units under different stress systems in the earth's crust, rocks at different depths where pressure and temperature vary, and rocks where the fluids already present have different compositions and overall salinities. If we had to categorize the surface topographic features of the United States on a cross-country automobile trip from Bangor, Maine to Los Angeles, California, and had to describe them to an overseas visitor, we would use terms like New England, the Appalachian Mountains, the Midwestern prairies, the Rocky Mountains, the Great Basin region of Utah, the Central Valley of California, and the Pacific Coast. We could certainly find terms for more regions along the way. Similarly with subsurface environments, we need to test the diversity of these reservoir rocks to ensure that we have the knowledge to carry out the goal of making carbon sequestra-

tion effective, safe, and worthy of the public trust. We simply cannot do that with a restricted agenda of just three or four such tests. In fact, a premise of the current sequestration regional partnership program is indeed to recognize that experience in a diversity of geologic settings helps us meet carbon sequestration goals.

While meeting these goals, we need to be mindful of costs. I would note that with respect to competitive awards, important competition has already occurred in one program area, the development of a regional partnership framework. The existing regional carbon sequestration partnerships were awarded competitively for both Phase I and Phase II.

These partnerships are open to growth and routinely offer collaboration with new members. Our Illinois Basin partnership has gained seven new corporate and NGO members in the last 18 months and more inquiries are being received. By building on the in-place partnership research framework we can maintain the momentum we now have, add regions and new members, more widely share the expertise already gained, and use expanded funding to better characterize the regions. The results achieved to date are the results of competitive proposal selection and recompeting these partnerships would be costly in both time and money.

Nevertheless, I would advocate additional funding for carbon capture and storage research, development, and demonstration at a higher level than authorized in this bill. The release of two Intergovernmental Panel on Climate Change reports since January 2007 has underscored the issues with respect to climate change. The urgency that has built up in the last few months on this issue is palpable. In the Illinois Basin, we are compressing some of our Phase II partnership work into an early Phase III transition to expedite the large-scale sequestration testing referred to in S. 962. We are seeking partners and building budgets. What we are finding is that costs are high. Deep, safely-constructed injection and observation wells can cost $2.6 million each, not counting staff to guide site selection, interpret results, and carry out concurrent environmental monitoring. Large compressor sets capable of delivering one-third of a million tons of CO_2 per year at high pressure (a "basic" large-scale test volume) cost about $10 million installed, can take a year from order date to delivery, and require the electrical equivalent of more than 5,000 horsepower to operate. In short, we need to add more funding in FY08 and FY09 than this authorization contemplates to both address innovative capture technology, test geological sequestration using CO_2 volumes approaching those emitted by major stationary sources, and carry out excellent environmental monitoring at these large-scale test sites. I would suggest that funding for FY08 be expanded to $125 million and that FY09 funding be expanded to $160 million. I believe these figures reflect both the scope of what is necessary and a financial commitment that could be effectively deployed using the sequestration partnership framework, the expansion of that framework, and new efforts, especially those that relate to research on innovations in carbon capture and to environmental assessments that help ensure public acceptance.

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